New Scientist

WEEKLY 17 October 2015

LITHIUM RUSH
Scramble for the world's most wanted element

BIG DATA, BIG BROTHER
China uses social media to rate all its citizens

COLLECTIVE MEMORY
How entire nations can forget the past

EMPTY CALORIES

Modern food is plentiful... but is it still good for us?

No3043
£3.90
US/CAN$5.95

9 770262 407251 42>

LOST IN SPACE We can't work out where anything is in the universe

EASY ON THE EYE.
EASY ON YOUR TAX RETURN.

The new BMW 3 Series 320d ED Sport stands out on the road with its eye-catching Sport Line styling, Star-Spoke alloy wheels and Sport leather seats. Drive a company car and it's easy to see the business case too, with lower CO_2 emissions making big reductions to Benefit in Kind Tax.

Staying connected while you're on the road is also easy, with BMW ConnectedDrive and BMW Business Navigation as standard.

Visit **bmw.co.uk/3series** to discover more.

THE NEW BMW 3 SERIES.
DRIVING PLEASURE, UNMATCHED.

Official fuel economy figures for the new BMW 3 Series Saloon: Urban 27.2–61.4 mpg (10.4–4.6 l/100 km). Extra Urban 46.3–85.6
style and conditions. BMW 320d ED Sport from 104 g/km, 18% BIK. Model shown in image is 109 g/km, 19% BIK with enhanced specification including 19" alloy wheels.

mpg (6.1 – 3.3l/100 km). Combined 36.7 – 74.3 mpg (7.7 – 3.8 l/100 km). CO_2 emissions 179 – 99 g/km. Figures may vary depending on driving

Lending subject to status and lending criteria.

Santander Trade Portal and Trade Club are available to Santander Corporate & Commercial customers.

Santander Corporate & Commercial is a brand name of Santander UK plc, Abbey National Treasury Services plc (which also uses the brand name Santander Global Banking and Markets) and Santander Asset Finance plc, all (with the exception of Santander Asset Finance plc) authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority. Our Financial Services Register numbers are 106054 and 146003 respectively. Credit cards are provided by Santander UK plc. In Jersey, Santander UK plc is regulated by the Jersey Financial Services Commission to carry on deposit-taking business under the Banking Business (Jersey) Law 1991. Registered office: 2 Triton Square, Regent's Place, London NW1 3AN. Company numbers: 2294747, 2338548 and 1533123 respectively. Registered in England and Wales. Santander and the flame logo are registered trademarks. Santander UK plc is a participant in the Jersey Bank Depositors Compensation Scheme. The Scheme offers protection for eligible deposits of up to £50,000. The maximum total amount of compensation is capped at £100,000,000 in any 5 year period. Full details of the Scheme and banking groups covered are available on the States of Jersey website (www.gov.je/dcs) or on request.

MC0032_1 SEP 15 HT

CONTENTS

Volume 228 No 3043

This issue online
newscientist.com/issue/3043

News

8

Undersea future for US cities

Large stretches of coastline will disappear thanks to sea-level rise

ROBYN BECK/AFP/GETTY IMAGES

On the cover

32

Empty calories

Modern food is plentiful… but is it still good for us?

Cover image
archetype/Shutterstock

Features

38

Lithium rush

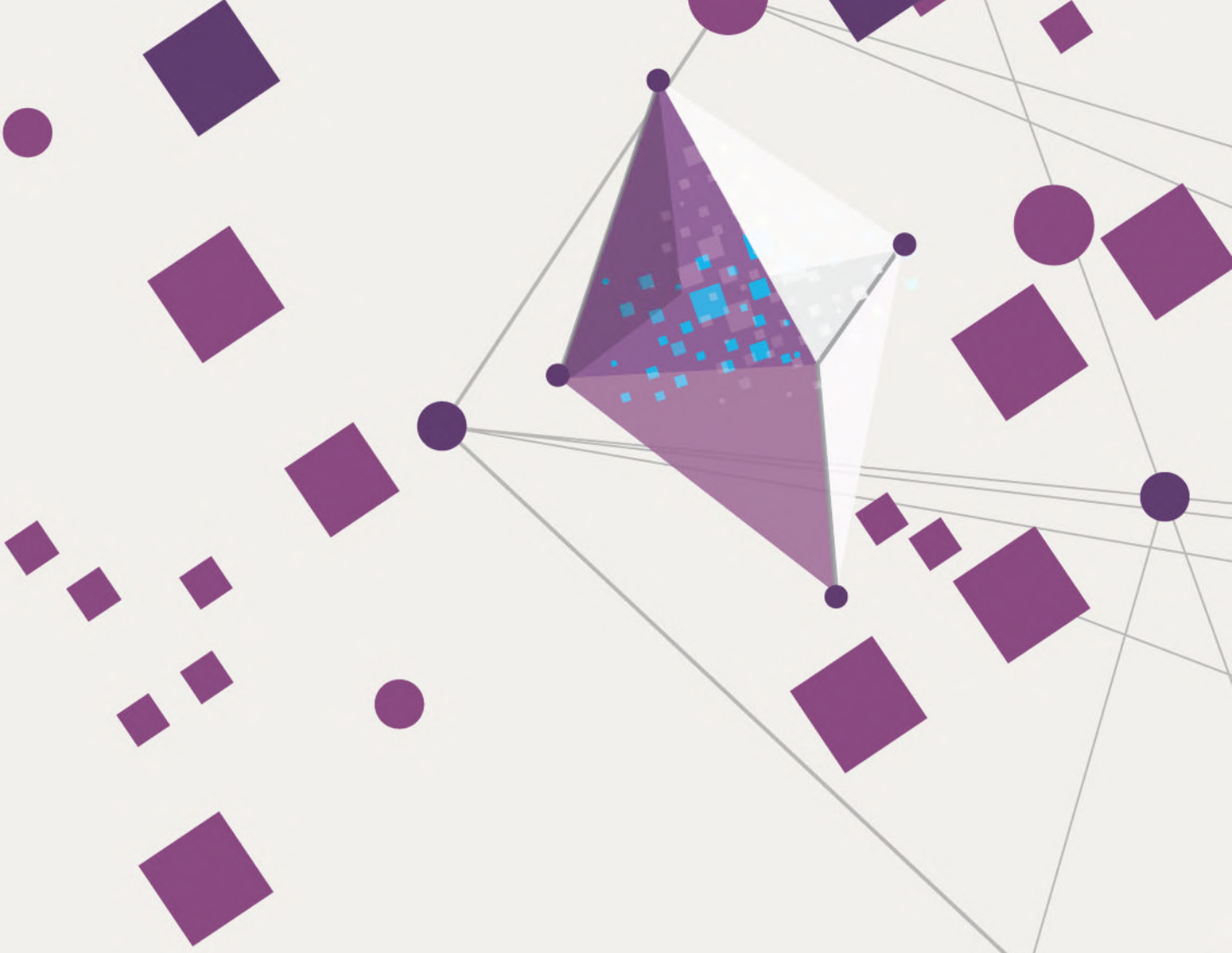
Scramble for the world's most wanted element

KARLA GACHET/PANOS

Coming next week…

Portal to another dimension
The vast structures shaking up the universe

Deeply troubling
The brain stimulation dilemma



Dream big, data.

Big data analytics is the preferred fuel for growth.

Today, every company's greatest strategic resource is its own untapped data. With HP, 100% of structured and unstructured data, including video and audio, can be used in real time to create real business insights that drive innovation, empower employees and surpass customer expectations. To find out more, visit us at hp.com/uk/furtherfaster.

NewScientist

LOCATIONS
UK
110 High Holborn,
London, WC1V 6EU
Tel +44 (0) 20 7611 1200
Fax +44 (0) 20 7611 1250

AUSTRALIA
Tower 2, 475 Victoria Avenue,
Chatswood, NSW 2067
Tel +61 2 9422 8559
Fax +61 2 9422 8552

USA
225 Wyman Street,
Waltham, MA 02451
Tel +1 781 734 8770
Fax +1 720 356 9217

SUBSCRIPTION SERVICE
For our latest subscription offers, visit
newscientist.com/subscribe

Customer and subscription services are also available by:

Telephone +44 (0) 330 333 9470

Email ns.subs@quadrantsubs.com

Web newscientist.com/subscribe

Post New Scientist, Rockwood House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH

One year subscription (51 issues)
UK £150

CONTACTS
Contact us
newscientist.com/contact

Who's who
newscientist.com/people

General & media enquiries
Tel +44 (0) 20 7611 1202
enquiries@newscientist.com

Editorial
Tel +44 (0) 20 7611 1202
news@newscientist.com
features@newscientist.com
opinion@newscientist.com

Picture desk
Tel +44 (0) 20 7611 1268

Display Advertising
Tel +44 (0) 20 7611 1291
displayads@newscientist.com

Recruitment Advertising
UK Tel +44 (0) 20 8652 4444
recruitment.services@rbi.co.uk

UK Newsstand
Tel +44 (0) 20 3148 3333
Newstrade distributed by Marketforce UK Ltd, 2nd Floor, 5 Churchill Place, Canary Wharf, London E14 5HU

Syndication
Tribune Content Agency
Tel +44 (0) 20 7588 7588
tca-articlesales@tribune.com

New Scientist is published weekly by Reed Business Information Ltd.
ISSN 0262 4079.

New Scientist (Online) ISSN 2059 5387

Registered at the Post Office as a newspaper and printed in England by Williams Gibbons (Wolverhampton)

THOMAS FRANZ/PLAINPICTURE

Not past its sell-by date

Buying fresh isn't the only way to get a healthy diet

AN ARMY marches on its stomach. Hence the offer of a 12,000 franc prize for help feeding Napoleon's army, awarded in 1810 to a way of preserving food in glass jars. Not long after, the tin can got its start, thanks to the British military.

Jars and cans duly made their way into civilian life. Frozen food joined them, thanks to Clarence Birdseye. Together, these innovations helped bring cheap, nutritious food to the masses.

But today, preserved foods are often seen as downmarket, albeit less so in the developing world, where they still signify quality. Celebrity chefs, food bloggers and glossy recipe books all suggest that we settle for nothing less than the freshest of produce.

That's not bad advice, but it's not realistic either. Neither lifestyles nor budgets allow for daily trips to the local grocer. Modern food production helps us out by offering abundance and convenience, but can reduce the quality of fresh food (see page 32).

There are many answers to this, including tweaking supply chains to make sure food stays fresher. We can also try to make foods more nutritious – but that may make them more costly too. And while some shoppers are happy to pay a premium for fortified food, grocers say that the more price-conscious customers won't swallow it.

Another alternative is to challenge the enduring snobbery over preserved foodstuffs, and point out where they are equal or even superior to "fresh" produce. With work, they could even come to seem the desirable option.

That might seem a tall order. But people around the world rejoice in preservation methods ranging from pickling to burial. There are connoisseurs who store prized tins of sardines for decades, turning them gently until they have matured enough to deliver a refined hit of flavour: last year, a pop-up café in London was dedicated to such fishy treats.

Making preserved food look desirable will take a broad effort: such stunts won't by themselves revamp its image. But they might help us get a taste for it. ■

What price the climate?

GOOD news: we may still be in with a chance to avoid massive sea level rise. Bad news: it will require far more rapid action than what's on the table for the climate treaty talks in Paris later this year.

A growing number of critics think the climate treaty process is fundamentally flawed because countries that spend lots of money to take a lead in emissions cuts risk losing out in the short term. This amounts to a global tragedy of the commons, because the logical strategy is for all involved to do as little as possible. On a bad day, it looks as though that's happening.

There is an alternative. Global carbon pricing – an agreed price for fossil-fuel emissions – could transform the nature of negotiations. Countries won't lose out by pushing for a high price, as it will only be implemented if almost all countries agree to it; those that don't participate may find themselves facing punitive taxes on their exports. And if the funds already planned to help developing countries cut emissions are linked to it, they will also have a reason to back a high carbon price.

It isn't going to be easy to gain leaders' support. But with so many regions of the world at stake (see, for example, page 8) it's a price worth paying. ■

XL CATLIN SEA VIEW SURVEY

Also available in colour, for now

The great coral die-off

A WHITE death is spreading across the world. Coral reefs are dying off as warming seas are made worse by the monster El Niño weather pattern heating up the Pacific Ocean.

The situation is so bad that the US National Oceanic and Atmospheric Administration declared a global coral bleaching event last week – only the third ever recorded. When corals are exposed for more than a month to temperatures they find too warm, they can expel the algae that live inside them and provide them with food. This leaves the coral a ghostly white. Some corals don't reacquire their algae and subsequently die, but most eventually recover.

Some 38 per cent of coral reefs will be bleached this year, says NOAA. About 12,000 square kilometres – 5 per cent of the world's coral – could be lost. So far this year, coral bleaching has been seen around the Solomon Islands and Hawaii in the Pacific and the Maldives in the Indian Ocean.

The event could affect hundreds of millions of people who rely on coral reefs for their livelihoods and for protection from storm surges.

It also gives researchers a chance to observe the die-off in real time, gathering data on whether and how different coral species around the world adapt to and recover from bleaching.

Hopefully, the bleaching events over the past two decades will have left corals better able to cope, says Mark Eakin, head of NOAA's Coral Reef Watch in College Park, Maryland.

Pluto's skies of blue

TODAY'S forecast for Pluto: blue skies, but watch your step. A double discovery from the New Horizons team shows Pluto with azure skies and patches of water ice on the ground.

"Water ice is brittle at such frigid temperatures and is the 'rock' making up Pluto's mountains"

By processing colour data in an image of Pluto eclipsing the sun that the New Horizons probe took after it flew past the dwarf planet in July, team members have revealed that Pluto's sky is a cool blue. That colour comes from blue wavelengths of sunlight scattering off of very small particles in the atmosphere. On Earth those particles are nitrogen, but on Pluto they are probably tholins, a class of clumpy organic molecules that originate in the upper atmosphere.

These molecules are also thought to be responsible for the reddish-brown hue that covers much of Pluto's surface. As the small tholins scattering blue light in the upper atmosphere stick together, they form larger, heavier grains that eventually settle onto the ground.

A small part of that ground is covered in water ice, which occurs in patches in craters and valleys. While frozen nitrogen and carbon have been seen on Pluto before, this is the first time frozen water has been spotted in decades of searching. Unlike other ices, which can flow like glaciers, water ice is brittle at such frigid temperatures and is the "rock" making up Pluto's mountains.

Lunar roboscope

POINT a telescope at the moon, and you might just spot one looking back. A robotic telescope, the first of its kind, has seemingly been operating flawlessly since it landed in 2013.

The 15-centimetre telescope is mounted on China's Chang'e 3 lander, which touched down on the lunar surface in December 2013. It sees in ultraviolet light, making it well suited for observations that are not possible from Earth.

During the telescope's first 18 months of operation, it observed for 2000 hours, monitored 40 stars and captured a picture of the Pinwheel galaxy (arxiv.org/abs/1510.01435).

Astronauts on the Apollo 16 mission had a manually operated UV telescope, but the Chinese telescope is the first to be operated remotely from Earth.

That's a challenge, because the moon is full of charged and abrasive dust that can get into equipment and destroy electronics. Despite this, the telescope has survived much longer than one year, its expected lifespan.

STUART C. WILSON/GETTY IMAGES

Unwelcome behaviour

Sexual harassment

ONE of the world's leading exoplanet hunters, Geoff Marcy of the University of California, Berkeley, has been found to have violated his institution's sexual harassment policy during a series of incidents involving students between 2001 and 2010. But the university isn't going to dismiss him – unless he does it again.

"It is clear that my behaviour was unwelcomed by some women," Marcy (left) said in a statement.

On Friday, BuzzFeed News revealed allegations from four women that Marcy had repeatedly engaged in inappropriate physical behaviour, sparking an investigation. Marcy has now agreed to "abide by clear expectations concerning his future interactions with students". Failure to do so could mean dismissal.

In an open letter, 22 members of the Berkeley astronomy faculty have called on the university to re-examine its response to the case. "We believe that Geoff Marcy cannot perform the functions of a faculty member," they write.

Prenatal cell trial

THEIR bones are so brittle, they fracture before birth. Now the world's first clinical trial of a stem cell therapy in the womb aims to help babies born with brittle bone disease start life with stronger skeletons.

Brittle bone disease, or osteogenesis imperfecta, is caused by mutations in the gene for making collagen – a tough, flexible material that strengthens bone. Transplanted stromal stem cells, which carry perfect copies of this gene, can be taken from terminated fetuses to help provide the much-needed collagen. The technique has been tried in a few fetuses, with promising results.

The pan-European project is set to begin in January 2016. The researchers aim to treat 15 fetuses and 15 babies who have the condition. By comparing the number of fractures in each group, they should be able to determine whether the earlier treatment is more beneficial.

"Collagen-providing stem cell transplants have been tried in a few fetuses, with promising results"

Flu drugs backed

MAYBE the drugs do work. An independent UK panel has concluded that Tamiflu and Relenza probably do help prevent deaths in flu pandemics, contrary to the arguments of campaigners.

The Academy of Medical Sciences and the Wellcome Trust, both based in London, set up the panel to examine claims that stockpiling antivirals for use in pandemics is a waste of money. The UK and the US have spent £560 million and $1.3 billion on such stockpiles, which are due for renewal.

Critics say there is no proof that Tamiflu or Relenza are any more help against flu than a stiff whisky, citing clinical trials of the drugs in treating ordinary winter flu. But the panel found that trials like these cannot be extrapolated to an epidemic or pandemic situation, in which severe flu is more common.

On the matter of stockpiling, the panel's report says that factors besides science influence government policy. But it does state that "should a circulating pandemic or seasonal strain result in greater prevalence of infection or severity of symptoms, the routine use [of these drugs] for all patients with influenza might become advisable".

Ebola survivor seriously ill again

IT'S the virus that doesn't quit. British nurse Pauline Cafferkey caught Ebola while working in West Africa last December. She survived, but this week is in a "serious" condition in an isolation ward in London, after experiencing renewed symptoms.

She reportedly sought medical help on 7 October but wasn't isolated until three days later. She had initially been diagnosed with "a virus" and sent home, despite her history. Now 58 close, recent contacts, including medical staff where she was first examined, are under surveillance. Some have received an experimental Ebola vaccine.

Cafferkey isn't alone. More than half the 13,000 Ebola survivors in West Africa are thought to be experiencing joint pain, fatigue and headaches that can be debilitating. These symptoms have been reported after other viral infections.

But other symptoms, such as eye problems, seem specific to Ebola. That's because the virus can survive in organs that are sheltered from the immune system, such as eyes and testes, even if someone seems cured of the disease.

So far, a quarter of people who survived the West African epidemic have developed severe eye problems, including an American doctor. US medical agencies are now recruiting Ebola survivors in Liberia for a study into what causes post-Ebola syndrome, and whether the lurking virus can infect others.

KEN MCKAY/ITV/REX SHUTTERSTOCK

Pauline Cafferkey (right) is back in isolation

60 SECONDS

Early warning

By 2100, spring will arrive three weeks earlier in the US than it did between 1950 and 2005. Leaves and flowers are expected particularly early in the Pacific Northwest and mountainous western US, which could affect migratory animals that depend on plants for food (*Environmental Research Letters*, DOI: 10.1088/1748-9326/10/10/104008).

No drugs for livestock

California has become the first US state to place tough restrictions on the use of antibiotics in livestock. The bill bans the routine use of antibiotics in healthy animals to prevent infection, a practice blamed for contributing to widespread antibiotic resistance.

Out of orca

To breed or not to breed? SeaWorld has been given permission to build a large pool at its killer whale theme park in San Diego, California – but only if it stops breeding them and bringing in new orcas to its park.

Prescription drug war

More than 800,000 chemist shops in India were expected to go on strike this week, in protest against online medicine sales. Chemists are arguing that, as well as threatening their businesses, online pharmacies are easy to abuse, allowing people to purchase medicines many times on the same prescription.

Have a seat

Being desk-bound may not be so bad. A study that followed 5000 people for 16 years found no association between sitting down and mortality risk. This suggests that the health risks of sitting for many hours a day may have been exaggerated. According to one researcher, standing up at work may be no better than sitting down, provided you get regular exercise (*International Journal of Epidemiology*, doi.org/79j).

US cities to sink under rising seas

We are committed to sea level rise that will flood land that is home to 10 million people

ROBYN BECK/AFP/GETTY IMAGES

Michael Le Page

IF WE carry on as we are, the land on which nearly 30 million people in the US live will end up below the sea's high-tide line. Even with drastic action to slash carbon emissions – more drastic than some think possible – 10 million homes will be submerged.

That's the conclusion of the latest study to look at how much sea level rise we are committing ourselves to over the coming centuries. "It's hard to imagine how south Florida and New Orleans can survive in the long run," says Benjamin Strauss of Princeton University. The US is set to lose a state-sized chunk of land, he says. "That should concern any American of any political stripe."

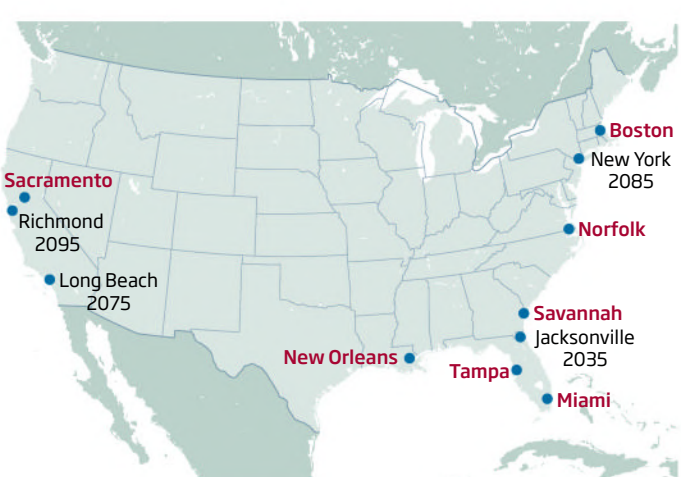
As things stand, sea level is likely to go up by around a metre by 2100, but the waters will keep rising for centuries or even millennia. According to an earlier study by Anders Levermann of the Potsdam Institute in Germany, every 1 °C of warming will lead to a rise in sea level of roughly 2.3 metres over the next 2000 years.

Now Strauss, Levermann and their colleagues have updated this study and worked out what it means for the US (see map, below). Half their scenarios assume that the West Antarctic ice sheet collapses, as several recent studies suggest is now inevitable.

If that happens, we will experience nearly 5 metres of sea level rise (*PNAS*, DOI: 10.1073/pnas.1511186112). This figure will rise even higher if we don't curb our emissions – in line with what an analysis by *New Scientist* concluded earlier this year.

Going, going... gone?

Some coastal cities are already **doomed to disappear beneath the waves** if we carry on emitting carbon dioxide as we are and the West Antarctic ice sheet collapses - and others will join them on the destined-to-drown list later this century



SOURCE: PNAS.ORG/CGI/CONTENT/SHORT/1511186112

The best case, according to Strauss and Levermann, is that sea level could be limited to an increase of around 2 metres (see graph, right). This depends on a number of optimistic assumptions. The first is that the rapid melting of parts of the West Antarctic ice sheet already under way stops. This could happen if changes in ocean circulation prevent warm currents reaching the base of the ice, Strauss says.

But without "aggressive action" to curb emissions, they say, not even changes in ocean circulation will stop the ice sheet's collapse. So to limit sea level rise to 2 metres, there must be rapid emissions cuts to keep global warming below 2 °C.

Cuts on that scale look increasingly unrealistic. Reducing emissions by this much requires either immediate action to curb the lifestyles of the jet-setting elite producing most emissions – which would be politically unacceptable – or sucking carbon dioxide out of the atmosphere, which would be exorbitantly costly on the scale required, says Kevin Anderson of the University of Manchester, UK.

Another assumption is that Earth's climate sensitivity – a measure of how much warming the planet will experience with a doubling of CO_2 in the atmosphere – is 3 °C. However, some studies suggest that over timescales of several centuries or more, sensitivity could be as high as 4.5 or 6 °C.

It is possible that sensitivity could be higher because of effects such as the release of methane – a potent greenhouse gas – as permafrost melts, Levermann says. "But the uncertainties are large."

"It's hard to imagine how south Florida and New Orleans can survive in the long run"

Rob DeConto of the University of Massachusetts-Amherst says his computer models of Antarctica back the idea that slashing emissions might prevent the loss of the West Antarctica ice

As sea levels rise, flooding looms

sheet. "It hangs in there," he says.

But for continued high emissions – the path the world is on – DeConto's work suggests there will be much higher sea level rises than Strauss and Levermann expect.

What's more, Strauss's study doesn't take into account temporary changes in sea level due to changes in ocean currents. Freshwater from melting Greenland ice is expected to shut down the Atlantic overturning circulation, leading to local sea level rises of up to 1 metre on the US East Coast.

No protection

Most think this won't happen for another century, but some think it could happen sooner. A temporary sea level jump of 128 millimetres on the US East Coast in 2009 and 2010 is thought to be partly due to a slowdown in the overturning current.

If the world fails to curb emissions and we end up committed to sea level rises of 5 metres or more, what can be done to save cities? That's far from clear. Flood barrier schemes like London's Thames Barrier and the Mose flood barrier in Venice are designed to protect against sea level rises of less than a metre.

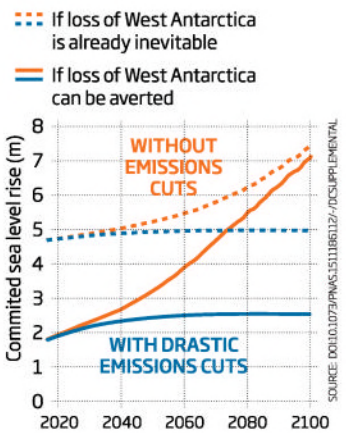
This type of barrier can't simply be made ever higher, because most cities have rivers flowing through them. If the barriers have to be kept closed for longer periods to keep sea water out, the river water will dam up behind them and cause flooding that way.

They are also extremely costly. A proposed barrier scheme for New York City would cost around $20 billion. Many settlements are likely to be abandoned because it will be too costly to protect them. The UK is already allowing some villages to fall into the sea along parts of its coastline.

"We are committing ourselves to changes that will take several centuries to millennia to appear," says Alexander Robinson of the Complutense University of Madrid, Spain. "It's not that in 2100 there will be 7 metres of sea level rise, but if we continue with high CO_2 emissions, we will guarantee that future generations will have to deal with such consequences." ■

Up to our necks

Big rises in global sea level are now unavoidable. Just how high the seas will rise depends on how fast we cut emissions and whether the West Antarctic ice sheet collapses



First pocket rockets take tiny satellites for a spin

THE next giant leap in space exploration could start with a small spin around the lab. A new propulsion system for shrunk-down satellites called CubeSats just passed a key lab test, and could be headed to space in the near future.

CubeSats, cheap, simple satellites built from off-the-shelf parts, promise a revolution in space exploration – but only if only we can steer them. Because they are so simple to build, they could open up space exploration to students and countries that lack their own space programmes, says Paulo Lozano at the Massachusetts Institute of Technology.

"We want to offer space access to people who don't have it," Lozano told a meeting of science writers in Cambridge, Massachusetts, on 11 October.

About 10 of the 1-kilogram satellites can hitch a ride into space with a larger payload. Once they're there, they can do serious science, from climate modelling to exoplanet hunting.

But they are also stuck in that orbit for their entire working lives. Not only does this limit their usefulness, but CubeSats can become dangerous space junk.

"If little satellites had the capability to move, we could do a lot of things that currently we cannot," Lozano says.

So Lozano and his colleagues are designing a propulsion system small enough to fit in your pocket that can steer CubeSats around low Earth orbit, or even out of the solar system altogether.

Instead of chemical fuel, which is heavy and inefficient, they use an ionic liquid, made entirely of positively or negatively charged ions.

Because the material is liquid at room temperature, it is safer and simpler to take into space than a plasma or gas. Applying an electric field can send these ions streaming away from the satellite at high speeds, producing a force in the opposite direction.

The theory was sound, but a few questions kept Lozano up at night. Would the ions left behind corrode the spacecraft? Would the spacecraft itself remain neutrally charged, or would the positive ions left behind pull the negative ions back in, cancelling out the thrust? And would the thrust be large enough?

This August, Lozano and his students tested the complete system in a vacuum chamber. The CubeSat was magnetically levitated to mimic space, and the thrusters were placed on opposite sides to push it in a circle, rather than having it fly around the lab. One thruster emitted positive ions and the other negative, keeping the craft neutrally charged.

After 20 minutes of continuous firing, the CubeSat spun at about 2 rotations per minute. Lozano says this would be enough to take a CubeSat from an altitude of 400

"If little satellites had the capability to move, we could do a lot of things that currently we cannot"

kilometres up to 800 kilometres, or to de-orbit it at the end of its life.

Next, the team fired the thrusters continuously for 140 hours, using up all the fuel without corroding the spacecraft.

"This is one of the other showstoppers we had at the beginning: will we be able to deplete all the ions from this ionic liquid?" Lozano says. "But we were able to get every single ion out. The tank was completely dry. This is the most exciting test we have run so far."

How long until the satellites are ready for flight? The team has given three of their propulsion systems to NASA's Glenn Research Center in Ohio, where they are running more tests. "It's up to them if they want to fly them," Lozano says. "I hope maybe this year or next year – we are extremely close."

Lisa Grossman ■

Quantum tech to hit the streets

Jacob Aron

YOU'VE heard of quantum mechanics, now meet the quantum engineers. After decades of being stuck in the lab, quantum science is about to emerge as a technology that will impact your everyday life. If ambitious plans succeed, by 2020 the UK could host the world's most powerful quantum computer, a secure quantum network spanning the country, and numerous other quantum-powered industries.

This mission kicked off in 2013, when UK chancellor George Osborne announced a £270 million investment in quantum technologies. Researchers are now setting up hubs to focus on particular areas – computing, communications, sensing and imaging – and aim to deliver useful quantum devices within five years, starting in 2015.

These teams held their first annual meeting, Quantum UK, at the University of Oxford last month to discuss the five-year road map and potential hurdles to overcome – not least the perception that quantum is too weird to be useful.

"When you talk to the general public about quantum physics, the first thing they think about is spooky philosophical things," Peter Knight of Imperial College London told the meeting. That needs to change. "That's our critical message: this is now developing technology."

Ian Walmsley, who heads the quantum computing hub at Oxford, says the basic science has progressed far enough to make this vision a reality. "It really now needed an engineering push to get us to the next level," he says.

Unlike an ordinary computer, which runs on binary bits, a quantum computer's "qubits" can be both a 0 and a 1 at the same time. This feature offers the potential for massive speed boosts when it comes to certain problems like searching databases or machine learning. But while binary bits are based on trusty silicon transistors, the jury is still out on the best approach for building quantum machines.

Walmsley and colleagues are working on a system based on trapped ions, individual charged atoms that are held in place by electromagnetic fields and zapped with lasers to read and write information. It's called Q20:20, because within two years they plan to build a 20-qubit device, pushing the limits of current quantum computers. By the end of the five-year programme they aim to connect up 20 of these into a 400-qubit processor. "That's big enough to do a number of things that supercomputers can't currently do," says Walmsley.

Qubit network

This modular design takes advantage of recent progress controlling trapped ion qubits in the lab, which showed that it is possible to successfully manipulate these fragile quantum states on a small scale. Now the Oxford group and others have designed a way to network these cells of qubits together into much larger processors. That means swapping one-off lab experiments for precision engineered quantum hardware.

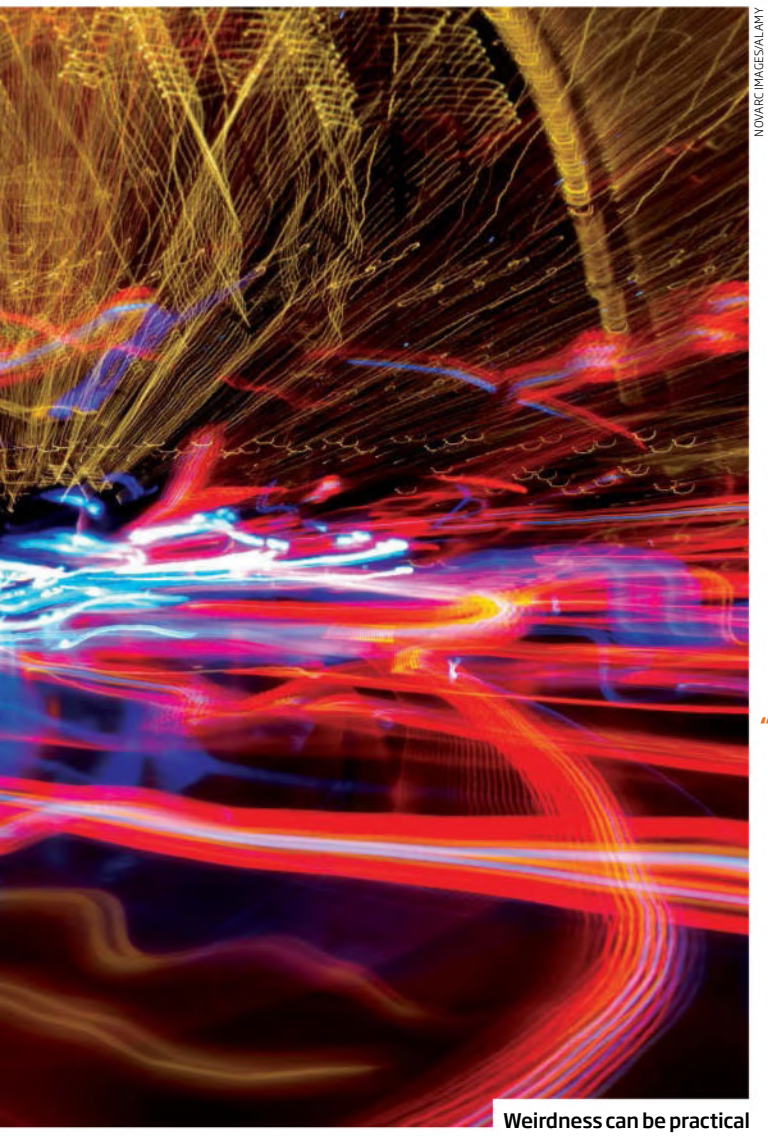
"What's available in the lab is already of the right performance," says Walmsley. "If we can show that one of these small-scale things works, then there is no barrier to scaling it up, other than manufacturing more components."

Since the computer is designed as a network, the qubit cells could potentially be scattered around the country, creating a kind of quantum cloud computer that many people can access – though the initial Q20:20 will probably be confined to a single lab, says Walmsley.

But you won't have to wait until 2020, as another kind of quantum network is already under construction in the UK and could be available to the public in just two years. Tim Spiller, who leads the quantum communications hub at the University of York is building quantum key distribution (QKD) networks over optical fibres around the cities of Bristol and Cambridge, with a plan to link the two across the country via London by the end of the five years.

QKD involves preparing

"You would never need to remember passwords or PINs again - QKD does all the work for you"



NOVARC IMAGES/ALAMY

Weirdness can be practical

photons in particular quantum states to generate and transmit a cryptographically secure key, which can be used to encrypt data for transmission over a non-quantum channel. Unlike existing cryptography, which relies on hard maths problems and can be cracked with sufficiently powerful computers, QKD is secured by the laws of physics: any attempt to intercept the key will raise the alarm.

Similar networks are already in place in the US and China for use by big business and government, but the UK network will be open to start-ups and even just interested tinkerers. "The idea is once it's in place, you can let people explore what can be done with it," says Spiller. "In Bristol the focus is on consumers who like looking at new technology," he says, while in Cambridge the network will be used by small, high-tech businesses in the area.

Current encryption techniques aren't yet under threat, but Spiller points out that QKD can ensure security over time. "There are certain sorts of data where people are concerned about the long-term threat of stuff being intercepted now and broken in the future," he says. "If you're exposing somebody's medical records or bank details, you don't want that to be broken in a number of years' time."

Quantum keys are one-use only, so you need to acquire a steady supply of them. John Rarity of the University of Bristol, and his colleagues are working on a credit-card-sized device that would let people pick up a batch from a point on the network, such as a bank ATM, and use them to log in to various services. "Consumers can access that store of keys and share them with a trusted source such as their bank or mobile phone provider," says Rarity. You would never need to remember passwords or PINs again – QKD does all the work for you.

Quantum devices in development at the other UK hubs, like cameras that can see

"Potential hurdles to overcome include the perception that quantum is too weird to be useful"

invisible gases or ultra-sensitive gravity detectors that can find pipes underground, have less consumer appeal, but could find wide use in construction and other areas. It might sound mundane, but digging up the wrong roads to fix pipes costs the country millions of pounds, said Knight. The goal is to make the UK a leader in quantum tech, says Rarity. "George Osborne invested because he wanted an industry."

Other countries are also pouring money into quantum engineering. "This is not unique to the UK," says Ronald Hanson of Delft University of Technology in the Netherlands. In July the Dutch government promised €135 million to develop quantum tech over 10 years, and last month computing giant Intel announced a $50 million partnership with Delft to explore how quantum processors could augment the next generation of high-end conventional computers. Meanwhile, in the US, organisations from Google to the Intelligence Advanced Research Projects Activity agency are pouring funds into quantum hardware.

Fundamental science isn't entirely being left behind as the precision made possible by newly engineered components will let researchers push ever further into the quantum realm, says Hanson, but it's clear that the shift into applications is under way. "The transition of quantum technology from the lab into the marketplace is an amazing thing to see, given we've been thinking about applications since the 1980s," says Rarity. "It's only really now that it's beginning to pay off." ■

STEP BY STEP

1981 Richard Feynman proposes the idea of a quantum computer

1984 Charles Bennett and Gilles Brassard describe a method for quantum key distribution

1985 David Deutsch proves that a universal quantum computer could tackle any problem an ordinary one can solve

1989 First QKD experiment transmits a secret key 32.5 centimetres

1994 Peter Shor invents a quantum algorithm to factor large numbers, the first practical use of a quantum computer

1995 First quantum logic gate built at the US National Institute of Standards and Technology

1998 First algorithm run on a 2-qubit quantum computer at the University of Oxford

2004 First QKD network operational between Harvard University, Boston University and research firm BBN Technologies

2011 D-Wave Systems starts selling what is claims are quantum computers, though this claim is disputed

2012 A quantum computer at University of Bristol, UK, sets a record for factoring numbers with Shor's algorithm, showing 21 = 3 x 7

INSIGHT Genetics and sexuality

GEORGE PANAGAKIS/PACIFIC PRESS/LIGHTROCKET VIA GETTY

Can a DNA test reveal sexuality?

Dean Hamer

THE idea of telling if someone is gay or straight from their DNA is highly provocative. So no surprise that a study entitled "A novel predictive model of sexual orientation using epigenetic markers" has caused a big stir.

Focusing on genetic testing may attract attention, but as a scientist long interested in the role of the genome in sexuality, I am more intrigued by what the work tells us about the role of epigenetic imprinting – the silencing of genes by methylation. This imprint can pass from parent to child and has implications for a range of complex human traits.

The first DNA markers for sexual orientation date back to 1993, when my lab at the US National Institutes of Health found an area on the X chromosome – Xq28 – that influences sexuality in gay brothers. Earlier this year, that finding was robustly confirmed in a study 10 times the size.

Despite such work, it was clear that inherited differences in DNA could not account for all of the observed variation in sexual orientation. That led me and graduate student Sven Bocklandt to hypothesise in 2003 that epigenetics may play a role. We illustrated this by suggesting how atypical imprinting of the X chromosome could lead to failure to inactivate feminising genes or activate masculinising ones, resulting in same-sex attraction in males. It could not be tested at the time, but some evidence came from X chromosome methylation patterns in mothers of gay men.

Bocklandt later headed to the University of California, Los Angeles, and tested imprinting directly by comparing the entire genome's epigenetic marks in male identical twins of whom one was gay and one straight. He looked at 30,000 methylation sites in all, but though several correlations turned up, this could not be repeated.

The latest study by Tuck Ngun, also at UCLA, scans 4 million potential methylation points (see "'I quit': concern over gay genetics", below). Five were identified which, together, could classify the sexual orientation of 37 gay/straight twin pairs with 67 per cent accuracy. Ngun sent an abstract based on preliminary data to the American Society of Human Genetics, hoping for feedback at its conference last week.

The society issued its own press release about the work to major media, and not surprisingly there were soon headlines about the new "gay gene test" and concerns about abuses, such as elimination of homosexuality via abortion. Some of the coverage created misconceptions that need correcting. Firstly, Ngun's work does not amount to a sexual orientation test. Even if it can be replicated in more twins with highly correlated methylation patterns, it is unlikely to work in unrelated members of the public.

What's more, the study doesn't discount the idea of genes directly influencing sexuality. There is room for genes and imprinting, and in fact they may synergise. That means epigenetics may only make a difference when combined with a certain genetic background.

Finally, such work won't worsen homophobia. People who understand the role of biology in sexuality are more likely to be accepting and inclusive.

I hope Ngun's findings will stimulate more research. My fear is that the furore stirred up will inhibit it. That would be a pity, because sexual orientation is one of the most fundamental and fascinating variations in humanity that we can study. ■

'I QUIT': CONCERN OVER GAY GENETICS

The scientist behind the latest study looking at how genetics might influence sexuality has abandoned research in the field.

Tuck Ngun of the University of California, Los Angeles, is concerned his work could be misinterpreted by those who seek to punish people for being gay. "I just left the lab last week," he says. "I don't believe in the censoring of knowledge, but given the potential for misuse of the information, it just didn't sit well with me." Ngun's work was based on the idea that a male pregnancy might leave a marker that affects subsequent pregnancies. This might be down to epigenetic changes – which switch genes on and off by adding or subtracting a methyl group.

He and his colleagues looked for epigenetic modifications made to the genes of 47 sets of male twins. Of the pairs, 37 were both gay while 10 pairs differed. Ngun's team found five gene regions in which methylation patterns differed between gay and straight brothers and used the results to develop a model that predicted sexuality with 67 per cent accuracy.

The study, presented at the American Society of Human Genetics annual meeting last week, has been criticised on several fronts. For a full report, see bit.ly/1jlECUg.
Jessica Hamzelou

Dean Hamer was the first to publish evidence for a genetic predisposition for homosexuality. He is now a scientist emeritus, author and film-maker

Intelligent Performance means staying ahead.
Even after 24 hours of fighting.

Saturday 13 June, 2015. Our mission: to capture Porsche's 17th overall victory at the 24 Hours of Le Mans with the pioneering 919 Hybrid. Its turbocharged 2.0 litre 4-cylinder engine, coupled with a groundbreaking system of electric motors, delivers about 1000 hp and makes it the most advanced Porsche ever built.

We had no slipstream to aid us but, holding true to our principles and guided by our ideas, we accomplished our mission. As the chequered flag fell we glimpsed the future of the sportscar, born in that very moment.

Mission: Future Sportscar.

To find out more visit www.porsche.co.uk/e-mobility

DMG MORI CHOPARD vodafone SCHAEFFLER FAG WEC

PORSCHE

Digital brain fires like the real thing

Jessica Hamzelou

BRAINS are going digital. A tiny piece of a rat's brain has been reconstructed in minute detail in a computer. The digital model, which includes 31,000 neurons and their 37 million synapses, fires like the real thing, and is already revealing fresh clues as to how the brain works.

The simulation is the first significant achievement of the Blue Brain project, which was launched 10 years ago by Henry Markram at the Swiss Federal Institute of Technology in Lausanne. The breakthrough represents the first step to a larger goal – creating a digital model of the entire human brain to probe consciousness itself.

So far, the digital brain recreates a piece of tissue about one third of a millimetre cubed. It contains 207 different types of brain cells and the millions of connections between them.

Markram and his many colleagues – a team comprising 82 people across 12 institutions – created their model using data they have been collecting for the last two decades. For 20 years, the teams have been pulling apart a brain region that is responsible for a rat's sense of touch. This tiny area has been sliced, stained, dissected and stimulated every which way. "This work represents a monumental amount of effort," says James Bednar at the University of Edinburgh, UK.

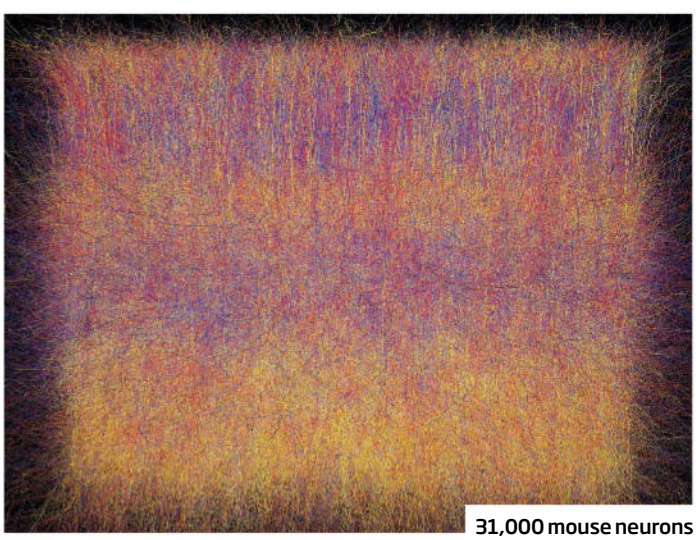
Using this information, Markram's team developed an algorithm to predict how the neurons connect with each other and fire together. After creating digital reconstructions of about 1000 of their recorded neurons, the team applied their algorithm to recreate 31,000 neurons, all connected to each other.

These make up a microcircuit, says Markram – a miniature network of neurons that communicate with each other. "It's the minimum size of a society of neurons," says Markram. The resulting model is the most detailed reconstruction of a brain to date (*Cell*, doi.org/78f).

"As one of the first concrete outputs from the billion-euro Human Brain Project this had to be a substantial piece of work, and it is," says Anil Seth at the University of Sussex in the UK.

Markram and his colleagues have already started putting their digital brain through its paces. When the group stimulated their model, mimicking how the living version receives information from other parts of the brain, they found that it responded like the real thing. "We see the same patterns of firing, with the same delay," says Markram. The digital brain could also adopt different states of activity – representing a sleepy or alert rat.

The digital brain imitates a real brain in other ways, too. For example, the team was able to spot what neuroscientists call "choristers" and "soloists" – neurons that fire in groups and alone. They also spotted triplets – neurons that fire in three beats. "They go pop-pop-pop, like Morse code," says Markram, who describes the model as a "first draft". "Ultimately we want to understand the mechanisms behind cognition, and what makes us do what we do," he says. ■



MARKRAM ET AL./CELL 2015

31,000 mouse neurons

First humans to leave Africa went to China

THE first humans to leave Africa decamped to far east Asia, not Europe. A trove of ancient teeth found in a cave in China adds evidence to the idea that humans reached the region thousands of years before they made it to Europe.

The find suggests that modern humans reached China between 80,000 and 120,000 years ago. That challenges the widespread assumption that humans didn't leave Africa until 60,000 years ago. It's further evidence that *Homo sapiens* may have left Africa several times, says María Martinón-Torres of University College London. "It means we have to re-think different models of our dispersal."

Our species emerged some 200,000 years ago in Africa and didn't make it to Europe until some 35,000 years ago. Martinón-Torres thinks that a combination of the competition from Neanderthals and the cold ice-age conditions may have kept them at bay. "*Homo sapiens* is a tropical species, so it was easier for them to move east than north," she says.

Martinón-Torres and her team found 47 teeth belonging to at least 13 *H. sapiens* individuals in the Fuyan cave in Daoxian, south-east China. The teeth were found under a layer of stalagmites that formed after the teeth were deposited there (*Nature*, DOI: 10.1038/nature15696). "The stalagmites are at least 80,000 years old, so that's the minimum age of the teeth," says Martinón-Torres. Given that the animal bones found at the same site were typical of the Late Pleistocene, this puts the upper age limit at 120,000 years ago.

Last year, Christopher Bae of the University of Hawaii described two teeth of modern humans in China, which suggested people reached the area as early as 100,000 years ago. He agrees that Martinón-Torres's study further weakens the traditional 'out-of-Africa-60,000-years-ago' model.

"We have to rethink our species' dispersal. Early humans may have left Africa several times"

So what became of those early arrivals? "We don't know what happened to the population, whether they simply vanished, and China was repopulated later, or whether they interacted with other hominins," says Martinón-Torres.

She hopes to find out if the ancient humans interacted with more primitive hominins already there, such as *Homo erectus*. She also calls for studies to see if these early arrivals in China have left a genetic imprint on people living there today. Andy Coghlan ■

Intelligent Performance means looking ahead.
Even after 60 years of innovation.

Born for the racetrack and victorious at the gruelling 24 Hours of Le Mans, Porsche E-Hybrid technology is now pioneering a new breed of sportscars. From the first plug-in Hybrid in the luxury segment with the Panamera S E-Hybrid to the 918 Spyder's record-breaking lap time of 6:57 at the Nürburgring Nordschleife.

And now with the Cayenne S E-Hybrid, a 416hp SUV that accelerates from 0-62mph in just 5.9 seconds yet delivers up to 83.1mpg on the combined cycle.

A demonstration of Intelligent Performance; a snapshot of tomorrow's sportscar on the road today.

Mission: Future Sportscar.

To find out more visit www.porsche.co.uk/e-mobility

PORSCHE

Official fuel economy figures in mpg (l/100km) - 918 Spyder: Urban N/A (N/A), Extra Urban N/A (N/A), Combined 85.6 (3.3), CO_2 emissions 79g/km. Panamera S E-Hybrid: Urban N/A (N/A), Extra Urban N/A (N/A), Combined 91.1 (3.1), CO_2 emissions 71g/km. Cayenne S E-Hybrid: Urban N/A (N/A), Extra Urban N/A (N/A), Combined 83.1 (3.4), CO_2 emissions 79g/km.
The mpg and CO_2 figures quoted are sourced from official EU-regulated test results, are provided for comparability purposes and may not reflect your actual driving experience. Electric range is dependent on driving conditions. Power output, performance and fuel economy figures obtained in combined hybrid power train mode using a battery charged from mains electricity.

MICHAEL S. YAMASHITA/CORBIS

Lives lost to mercury poisoning

Map of genes that turn mercury toxic

Joshua Sokol

THE sleepy fishing village of Minamata, Japan, 1956: physicians are baffled by a 5-year-old girl who has trouble walking and talking. Her suite of symptoms is like nothing the medics have seen before. Two days later, the girl's sister develops the same symptoms – and other cases quickly follow.

We now know that mercury poisoning was to blame: local industry had released the metal into the sea, where it accumulated in fish and shellfish as methylmercury – an organic form that is particularly easily absorbed by the body. Minamata disease has since claimed about 2000 lives.

Methylmercury is now recognised as a neurotoxin, but we know little about it, other than that microbes make it from mercury, and that it builds up in animals further along the food chain, including us.

In 2013, a team at Oak Ridge National Laboratory in Tennessee identified two genes – *hgcA* and *hgcB* – that seem to enable microbes to make the toxin. Now, that team, led by Mircea Podar, has looked for those genes in samples from a range of environments globally. Their work shows that methylmercury is produced by more bacterial types in a wider range of ecosystems than we thought.

"Some of the highest counts of the methylation genes were in melting permafrost, in Arctic Alaska," says team member Dwayne Elias, also at Oak Ridge. This is worrying, he says, because with climate change, annual thaws will continue to let mercury pollution run off from melting snow into the tundra, where it can be converted into methylmercury.

Wastewater treatment plants and bioreactors also seem to host bacteria with the genes for methylmercury production.

The genes aren't everywhere, though. They don't appear in the human gut – or, apparently, in vertebrate gut flora more generally. But they are present in the invertebrate microbiomes the team examined.

Another mysterious absence is in the open ocean. It's important to know how methylmercury builds up in the fish we eat – but bacteria in that ecosystem don't seem to have the genes (*Science Advances*, doi.org/79k).

Taken together, the results underscore just how widespread methylmercury production is in the wild, says Elsie Sunderland at Harvard University.

The ability to map methylmercury genes is important, given that 18 countries have now joined the Minamata Convention. The UN-brokered agreement aims to limit methylmercury exposure worldwide – and is named after the Japanese village where research into the neurotoxin began almost 60 years ago. ■

Blocking brain chemical could stop migraines

FLASHING lights, a feeling of unease, excruciating pain. The varied symptoms of migraines can be triggered by hunger or stress, but their underlying cause has remained a mystery. Now it seems a molecule deep in the brain may be to blame.

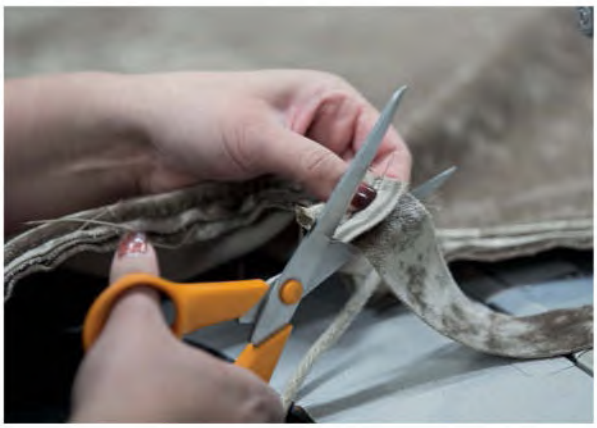
To investigate, Simon Akerman at New York University and Peter Goadsby at King's College London studied two peptides released by neurons thought to be involved in migraine pain. Called VIP and PACAP, these protein-like molecules first raised suspicion when large amounts were found in blood taken from people during migraines. When they were given intravenously to volunteers, they got a headache or migraine about 2 hours later.

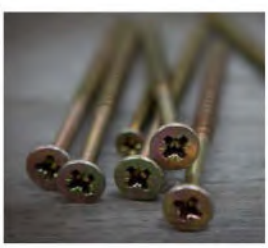
To study the effects of these chemicals on a set of neurons in the head and face that are known to trigger headaches, Akerman and Goadsby gave some rats PACAP and others VIP. But they found that only PACAP caused the neurons to increase their activity – about an hour and a half after it was injected (*Science Translational Medicine*, doi.org/787). This suggests that PACAP is responsible for kick-starting a migraine, says Akerman.

To stop this neuron activity, Akerman and Goadsby used molecules that block the receptors on neurons that PACAP binds to. The drugs made no difference when injected into the rats' blood, but when they were injected directly into the brain, the neurons responsible for headaches no longer showed activity surges. "These receptors could represent a new therapeutic target for migraine," says Akerman.

"When the peptides were given to volunteers they got a headache or migraine about 2 hours later"

"It appears that these receptors are important, and that this is vital to helping us understand migraine and for developing new treatments," says Debbie Hay at the University of Auckland in New Zealand. "The receptors are a new and exciting target for migraine." Jessica Hamzelou ■

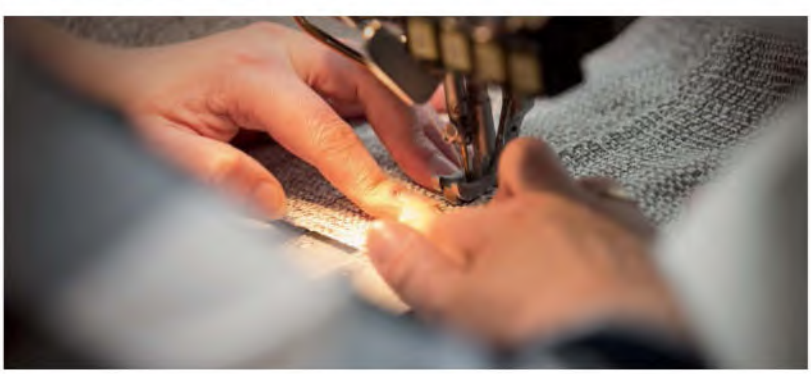




we're ready

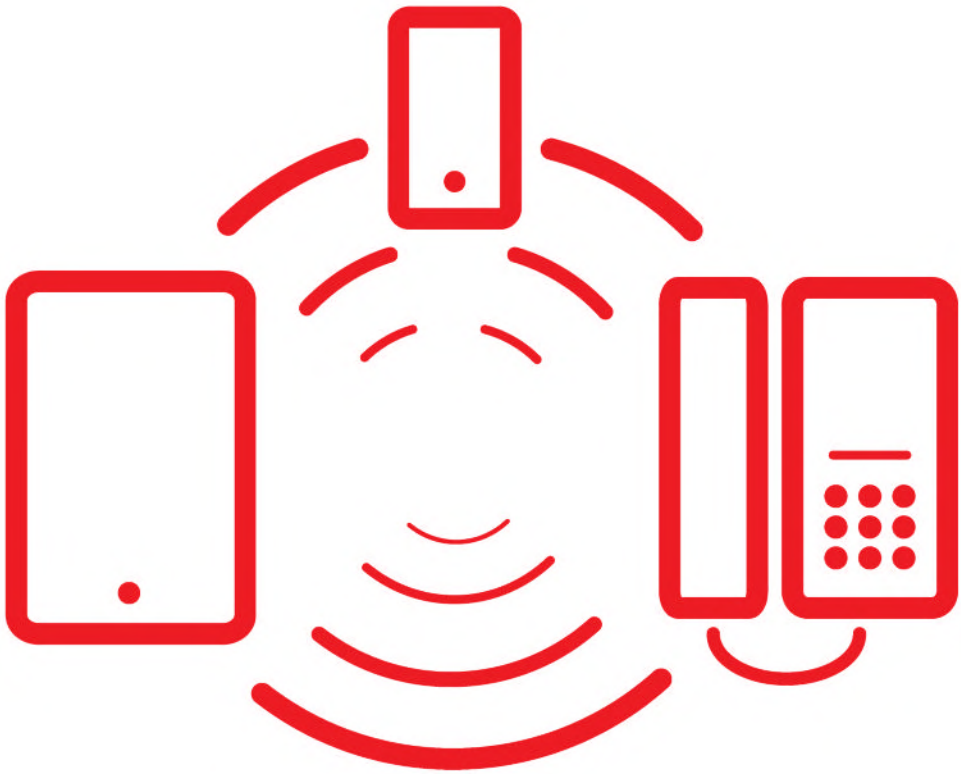
All our sofas are handmade to order, many in our own UK workshops. When you choose a DFS new season collection sofa our skilled craftspeople will get to work making it in the fabric and finish of your choice. And if you order your new sofa now it's guaranteed to be delivered in time for Christmas.

Tammy is a Quality Controller and David is a Fabric Cutter from our DFS Derbyshire workshop. Visit **dfs.co.uk/meetourteam** to find out more.



TEAM GB | OFFICIAL PARTNER

dfs



Never miss a call with One Net Business

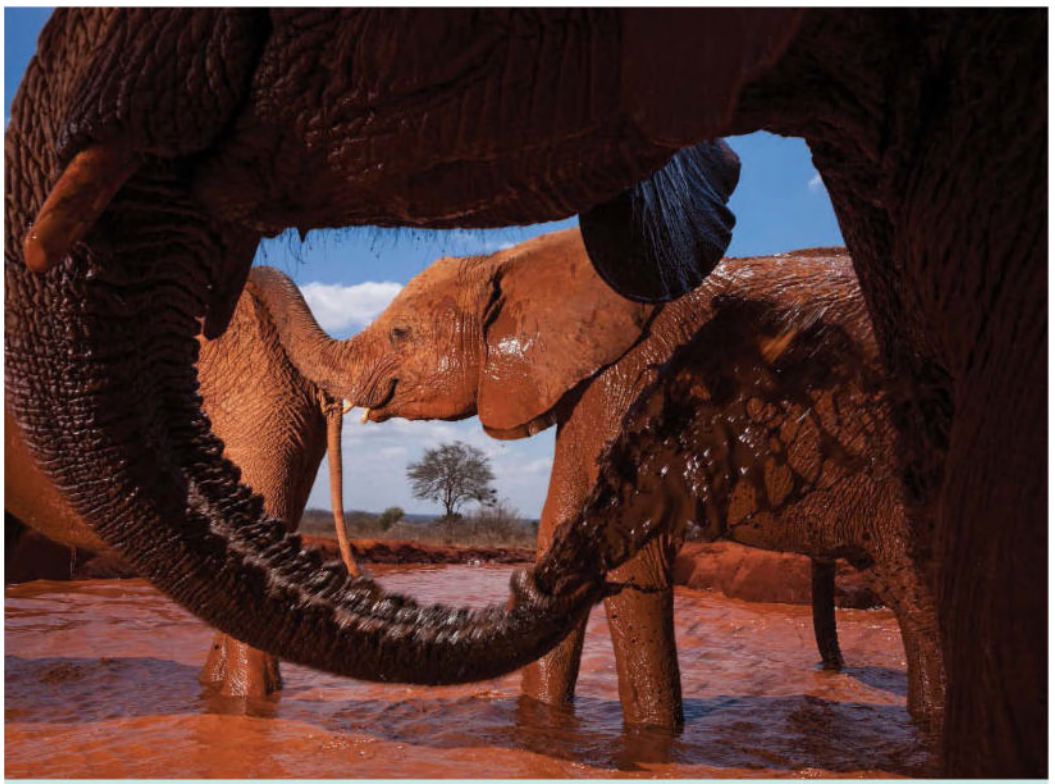
A Ready Business is always there for its customers. **Vodafone One Net Business** seamlessly connects fixed and mobile communications – one number works across every desk phone and device. So, wherever staff are, they never miss a lead or opportunity.

Find out more at **vodafone.co.uk/onenetbusiness** or call **08080 044644** for free.

Ready Business Fixed | Mobile | Cloud

Vodafone
Power to you

All calls free. Lines open, 8am-6pm Mon-Thurs and 9am-5pm Friday.



MICHAEL NICHOLS/NATIONAL GEOGRAPHIC CREATIVE

Elephants armed with genes that stop cancer

CANCER is no match for elephants – and now we might know why.

Big animals like elephants live longer and their cells have to divide more. This means we would expect them to be more susceptible to cancer, but that doesn't seem to be the case.

This is known as Peto's paradox, and Joshua Schiffman at the University of Utah and his team have confirmed that it is real. Using data on captive elephants worldwide, they found that less than 5 per cent of elephants die of cancer, compared with 11 to 25 per cent of humans.

The secret seems to be in their genes. By analysing elephant blood, the researchers found that African elephants have at least 20 versions of the *p53* gene.

This gene protects against cancer because it detects damage in a cell, and can stop it from dividing or cause it to self-destruct. Humans have only one version of it, inheriting one copy of it from each parent.

The many elephant versions of the gene could explain why the team found that elephant cells are twice as likely to self-destruct after dangerous radiation exposure, probably preventing tumour formation (*JAMA*, doi.org/772).

Their findings are supported by a second, independent paper published by a University of Chicago team last week (*BioRxiv*, doi.org/773).

Back-to-Africa migration in ancient DNA

IT'S amazing what you find in old genes. DNA recovered from the skeleton of a man who lived in Ethiopia 4500 years ago reveals clues about humans' migration back to Africa in antiquity.

Evidence from modern genomes suggests that there was a substantial movement of people from west Eurasia back to Africa – the cradle of humanity – about 3000 years ago. But there has been no ancient African DNA to study to investigate further. Recovering DNA from ancient skeletons is difficult as it quickly breaks down, especially in the warm climates found in Africa.

However, Ron Pinhasi at University College Dublin in Ireland and his colleagues found it was possible to extract large amounts of DNA from the petrous part of the temporal bone at the base of the skull, the densest bone in the mammals. When compared with modern genomes from across Africa, the DNA they extracted from this part of the 4500-year-old skeleton shows that 4 to 7 per cent of the genome of most African populations can be traced back to Eurasia (*Science*, doi.org/78d).

This "backflow" of Eurasian DNA reaches across the continent, confirming the findings of a study of modern genomes that was published last year.

Can stars puff up their planets?

THEY would be the pufferfish of outer space. A long-standing riddle would be solved if planets of the same mass as Jupiter balloon in size when their host stars reach the end of their lives.

Some gas giants are twice as large as expected, given that gravity should put a cap on their maximum size. Two main theories have emerged to explain these inflated Jupiters: either irradiation from the star warms their atmosphere, slowing down their collapse; or the star's heat penetrates the core of the planet, inflating it from the inside.

Eric Lopez at the University of Edinburgh, UK, thinks looking for swollen planets around a red giant star – which emit huge amounts of energy – would give us evidence for one of these mechanisms.

Should these planets exist, they would show that gas giants can inflate them from the inside (arxiv.org/abs/1510.00067).

Squirrel monkeys learn to use cups

IT'S not the height of etiquette, but it's a start. Squirrel monkeys in captivity have learned to eat and drink from cups.

The only other non-human primates that have been seen to spontaneously use containers are captive chimpanzees, orangutans and capuchin monkeys.

The monkeys' food comes in chunks too large to eat in one go. Christine Buckmaster of Stanford University and her colleagues found that the animals learned to bite off a mouthful while holding the cup to catch the rest.

Some also learned to collect water from a fountain and carry it to a distant perch, where they could sip away at their leisure (*American Journal of Primatology*, doi.org/78q).


Aspen is a Ready Business
For retail fitting specialist Aspen Concepts, being Ready means never missing a call. One Net Business connects fixed and mobile to make one number work for every phone or device. So their people can be out and about more, without ever missing a lead or opportunity.
Find out more at vodafone.co.uk/onenetbusiness
Ready Business Fixed | Mobile | Cloud
Vodafone
Power to you

Robber ants live in caste of their own

ANT burglars. Some Costa Rican ants devote their lives to stealing food from neighbouring nests – and the way they behave suggests they have finessed the art of theft.

"It's not an average day when you discover that a whole new caste of ants exists," says Terrence McGlynn at California State University.

McGlynn and his colleagues already knew of reports that some *Ectatomma ruidum* ants steal from other nests. So they studied 47 ant thieves to see how they behaved and found that they displayed a sneaky behaviour, taking food from one nest and bringing it back to their own. They are devoted to the task, in the same way soldier ants spend their lives protecting the nest.

The thieving ants aren't merely foraging ants that get their food from other colonies, says McGlynn. "When you watch thieves, they act like they're working to avoid detection. If you grab them, they drop their stolen food. Regular non-thieving foragers will hang onto their food, as they know it was rightfully acquired."

Their behaviour is very different from your typical worker ant, says co-author Hope Jahren at the University of Hawaii. "They know they are doing something wrong. Guilty little ants." (*Animal Behaviour*, doi.org/78m).

BENOIT GUENARD

Light without an echo could peer deeper into our bodies

IT'S a call with no response. A new way of creating waves that don't echo promises to improve everything from your Wi-Fi signal to medical imaging.

As a wave travels it can become scattered, like an echo. This is a problem in telecommunications: if you send digital signals down a very long optical fibre, the pulses stretch out and the 1s and 0s start to blend into one another.

Now Joel Carpenter at the University of Queensland in Brisbane, Australia, and his colleagues have demonstrated a way to get around this.

The team started with a fibre-optic cable 100 metres long and shone light through it. As expected, the light emerging at the other end had become distorted.

They measured the exact degree of distortion and how the profile of the pulse changed on its journey through the fibre. This shape determines what path photons take down the fibre, and how they interfere with each other, Carpenter says.

Finally, they created a light pulse with the exact cross-section needed to counteract the distortion and emerge from the fibre intact – and found that it did just that (*Nature Photonics*, DOI: 10.1038/nphoton.2015.188).

"Even though it might get scattered as it goes through, it will all semi-magically show up at exactly the same time at the other end," says Carpenter.

The scheme could have important applications, for instance, allowing medical imaging devices to peer deeper into tissue than is now possible.

Birth month affects later dementia risk

THE month of your birth influences your risk of developing dementia. Although the effect is small compared with risk factors such as obesity, it shows how the first few months of life may affect cognitive health for years to come.

Gabriele Doblhammer and Thomas Fritze from the University of Rostock, Germany, studied data from nearly 150,000 people in Germany aged 65 and over. After adjusting for age, they found that those born in the three months from December to February had a 7 per cent lower risk of developing dementia than those born in June to August (*Kölner Zeitschrift für Soziologie und Sozialpsychologie*, doi.org/78c).

The researchers say the study can't tell us anything directly about the mechanisms underlying the correlation between birth month and dementia risk later on – but poor nutrition tied to seasonal food availability might play a part, as this may directly affect brain development at a critical time.

What's more, summer babies face their first winter sooner, and winter respiratory infections at an earlier age might have subtle, long-lasting effects.

NASA/JPL-CALTECH/MSSS

Curiosity sits in dry Martian lake bed

BUILDING rovers to cope with today's Martian environment is tough enough, but 3 billion years ago there would have been another challenge: teaching them to swim.

Last week saw news of modern Mars water running down hills and disappearing. But in Gale crater, where Curiosity is poking around, water once pooled into a lake – and then sat there, placid, for hundreds or thousands of years at a time.

Researchers have long suspected that Gale crater once hosted a lake, but Curiosity's recent travels have built up the case considerably. For instance, the Curiosity team has identified S-shaped deposits that resemble river deltas (*Science*, doi.org/78n).

The lake may have been fed by ice on the northern rim of the crater, which rose 2 or 3 kilometres above the water level.

"What we learned from the rocks is that these are not catastrophic flood events," says John Grotzinger of the California Institute of Technology. "They seem to be sustained flows of modest velocity, ankle to waist deep, the kind of flow that might have made an exciting canoe ride."

Big brother is rating you (if you're Chinese)

Digital tracking is now a fact of life. In the first instalment of a two-part special on how our data may be used or misused, **Hal Hodson** considers what happens to privacy if your government is bent on giving all citizens a personal character score – and whether that's entirely a bad thing

Paging Winston Smith

BOTTOM LEFT: FERNANDO MOLERES/PANOS PICTURES. TOP RIGHT: IAN BERRY/MAGNUM PHOTOS.

WHERE you go, what you buy, who you know, how many points are on your driving licence: these are just a few of the details that the Chinese government will track – to give scores to all its citizens.

China's Social Credit System (SCS) will come up with these ratings by linking up personal data held by banks, e-commerce sites and social networks. The scores will serve not just to indicate an individual's credit risk, for example, but could be used by potential landlords, employers and even romantic partners to gauge an individual's character.

"It isn't just about financial creditworthiness," says Rogier Creemers at the University of Oxford, who studies Chinese media policy and politics. "All that behaviour will be integrated into one comprehensive assessment of you as a person, which will then be used to make you eligible or ineligible for certain jobs or social services."

One of the earliest planks of the system is Sesame Credit, built and

"The aim is to collect nearly every aspect of citizens' lives and share it between public bodies"

run by Ant Financial, a subsidiary of the Chinese e-commerce giant Alibaba. It assigns people a score of up to 950 points based on factors such as how often they shop and their general credit history. Spending more through Alibaba's payment app, Alipay, or connecting to more friends via Sesame Credit can raise your score.

The higher your score, the more privileges it opens up. People scoring above 600 can rent cars from the Chinese companies Car Inc and eHai.com, without putting down a deposit. A score above 650 lets you check out of hotels faster, while more than 700 cuts the paperwork when applying for visas to Singapore. Individuals are already boasting about their high scores on Chinese social networks.

"Sesame Credit is one piece in the bigger picture," says Clement Chen, a privacy law specialist at the University of Hong Kong. By 2020 – the deadline for the full version of SCS to be up and running – the system will take into account points on your driver's licence and how doctors, lawyers or teachers perform at work, says Creemers.

Mega-platform

The Chinese government already has a website that will allow citizens to check out others' credit rating, although it's still being built. Run with help from Baidu, China's main search engine, it uses data from 37 central government departments and also displays interactions with the state, such as any court judgements against individuals. Its functionality will be ramped up over the coming years and will presumably be linked with a future version of Sesame Credit.

The real threat to privacy will come when the government collates myriad other sources, painting a complete picture of its citizens in data, says Chen. "It aims to collect nearly every aspect about citizens and integrate it into a mega-platform, so this information can be shared between public bodies."

Unsurprisingly, Sesame Credit has received some negative press in the West. Articles have repeatedly claimed that it would take the behaviour of people's friends into account when determining their score, and that it would monitor individuals' social media activity.

In a statement sent to *New Scientist*, Ant Financial refutes some of these claims. "Materials published on social media platforms do not affect our users' personal Sesame Credit score," the company says. Chen says he isn't aware of any part of the system that judges individuals on the behaviour of their friends.

Creemers, who translated publicly released Chinese government documents detailing SCS into English, says the negative reaction to the project is typical of the Western media's coverage of China. "Pretty much anything China does makes people panicked," says Creemers. "And many times we don't recognise that we are doing similar things."

People in the West are often tracked just as relentlessly – but by corporations seeking profits (see "The West is watching, too", below). Of course, that doesn't mean China's intent to monitor and score its populace isn't worrying.

Sesame Credit and similar systems built by other Chinese tech companies certainly match the requirements outlined by the government for SCS, but the link between what the government wants and what these companies are doing is never explicit, Creemers says. Instead, he says, the government supports products that suit its purposes, and lets those that don't wither.

"The government has been very aggressive in supporting the development of WeChat as opposed to Weibo, for example," says Creemers. The public nature of Weibo, China's answer to Twitter, allowed people with dissenting views to build a big following, whereas WeChat, akin to Whatsapp, is more contained.

Sesame Credit is open about its links with the Chinese government. "Sesame Credit works closely with the Ministry of Public Security, the Supreme People's Court, the Ministry of Education and the State Administration for Industry and Commerce to collect data," an Ant Financial spokesperson said.

Keep in line, thanks

Construction of the SCS is already well under way. In June, the government announced that every organisation in the country – companies, NGOs as well as government bodies – would be given a unique identification number to facilitate the monitoring of their activities.

Chen says that the "mega-system" is designed to limit a wide range of risks, not just financial ones: "non-compliance with contracts, insincerity in selling goods, or failing to comply with safety standards during the production of drugs or the construction of a bridge", for example. "It covers business actors, as well as individuals.

"I am curious about how serious the government is about scoring food and drug safety," he adds. "That could be a part that most of the Chinese public would say yes to."

Chen says the scoring and monitoring of businesses is welcome, but that applying the same level of surveillance to individuals is worrying. "One might think of it as a mega-surveillance system, as almost every aspect of citizens' lives can be interpreted," he says.

Christo Wilson, a computer scientist at Northeastern University in Boston, suggests that SCS may spawn a kind of black market in which people can pay for fake online profile details which will boost their scores, much like existing grey areas in which social network followers can be "bought" and "likes" on posts paid for.

"The more important you make that number, the more people are going to try to manipulate it, and the more data you include, the easier it becomes to manipulate it," he says. "Affixing that kind of value to social information, the black market is going to go crazy." ■

THE WEST IS WATCHING, TOO

Just as in China, people who live in the West are being tracked and ranked all the time. For now, though, this is serving commercial interests rather than those of the state.

One burgeoning area is that of creating alternative credit scores for individuals, based on "any kind of algorithm using non-traditional data", says Christo Wilson at Northeastern University in Boston. "That is almost entirely unregulated." Any firm with a dataset can build its own scoring system. "There is no requirement that they be transparent or even notify you that they are doing such a thing," he says.

Giant data brokers like Axion track the things you buy in order to build a psychological profile that marketers can use to sell to you. Social lending companies like Upstart base their loan decisions on social media data, as well as traditional credit scores. US tech giants like Google, Facebook and Amazon hold huge swathes of data, far more than is apparent to most of their users.

Softly-softly approach

A subtle suit could help rehabilitation, finds **Anna Nowogrodzki**

IT'S enough to put a spring in your step. A soft robotic suit has helped three people recovering from a stroke to walk better.

The suit, developed by a team led by Conor Walsh at Harvard's Wyss Institute, is made of flexible fabric that attaches to the waist, thigh, calf and shoe. Cables fastened to the outside of the suit can contract in the same directions as muscles, helping to move the legs.

The three people who tested the suit – one woman and two men, aged 29, 60, and 63 – could already walk, albeit with impairments. Using the suit, they took 11 per cent less time between steps and walked more symmetrically. Its support could prevent injuries that arise from compensating for a weaker leg, and help people recovering from a stroke to do more of their rehabilitation at home or while out and about, rather than in the clinic.

"They're improving pretty fast in getting things lighter and more efficient," says Herman van der Kooij, a biomechatronics researcher at the University of Twente in the Netherlands.

Walsh's team presented the work in August at the 2015 IEEE International Conference on Rehabilitation Robotics in Singapore (doi.org/789).

Exoskeletons are already in use for other kinds of rehabilitation. People paralysed from the waist down can use rigid exoskeletons to take basic steps, controlling the suit either with their upper body or an EEG skull cap. Other exoskeletons are designed to help people walk while carrying heavy loads, often aimed at soldiers hefting heavy packs over long distances. A battery-powered ankle exoskeleton tested on healthy people by Hugh Herr at the Massachusetts Institute of Technology was the first to make walking more efficient.

But all of these set-ups have drawbacks. Hard exoskeletons are much more expensive than wheelchairs, and to be practical, their prices need to decrease about tenfold, says van der Kooij. It's also a challenge to align a rigid robot's joints with the body's joints, and misalignment can cause injury or stress. What's more, exoskeletons are heavy, so if a patient falls they may not be able to get back up. The obvious visibility of the suits can also seem a source of stigma for their wearers.

"For most people, a soft robot suit will be socially preferable to having a huge kind of Iron Man suit"

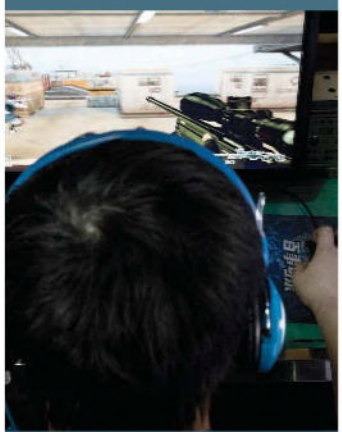
Walsh's prototype is more discreet, but still not low-profile enough. The volunteers had to be tethered to a motor on a trolley, which powered the suit. His team is planning another model in which the motor can be worn on the body. The team also wants to generate more force to boost walking efficiency.

Nevertheless, soft exoskeletons might be better accepted than rigid models. "The soft solutions hinder natural motions less, and also tend to be more lightweight and smaller so you can wear them under your clothes," says van der Kooij. "I think for most people that will be socially preferable to having a huge kind of Iron Man suit." ■

JAVIER LARREA/GETTY

One step at a time

ONE PER CENT



Gamers' placebo

Even in virtual worlds, life is what you make of it. Gamers have more fun when they think a game has been updated with new features – even if that's not true. Researchers at the University of York, UK, tested for the placebo effect by telling some gamers they were about to play against advanced AI, others that the game was random. Those playing an AI rated the game better overall and said they enjoyed it more (*CHI Play*, doi.org/10/79b).

10,000

The number of municipal problems fixed in Detroit in the past six months, after being reported via the "Improve Detroit" app

Hands-freeway

Are you ready for a world where cars change lanes on their own? This week, Tesla Motors is rolling out version 7 of the software that runs its electric cars. The "autopilot" features enable Tesla cars to change lanes without the driver touching the steering wheel, and to park themselves. The software means it is now possible to drive for hundreds of kilometres without touching the controls.

FERNADO MOLERES/PANOS

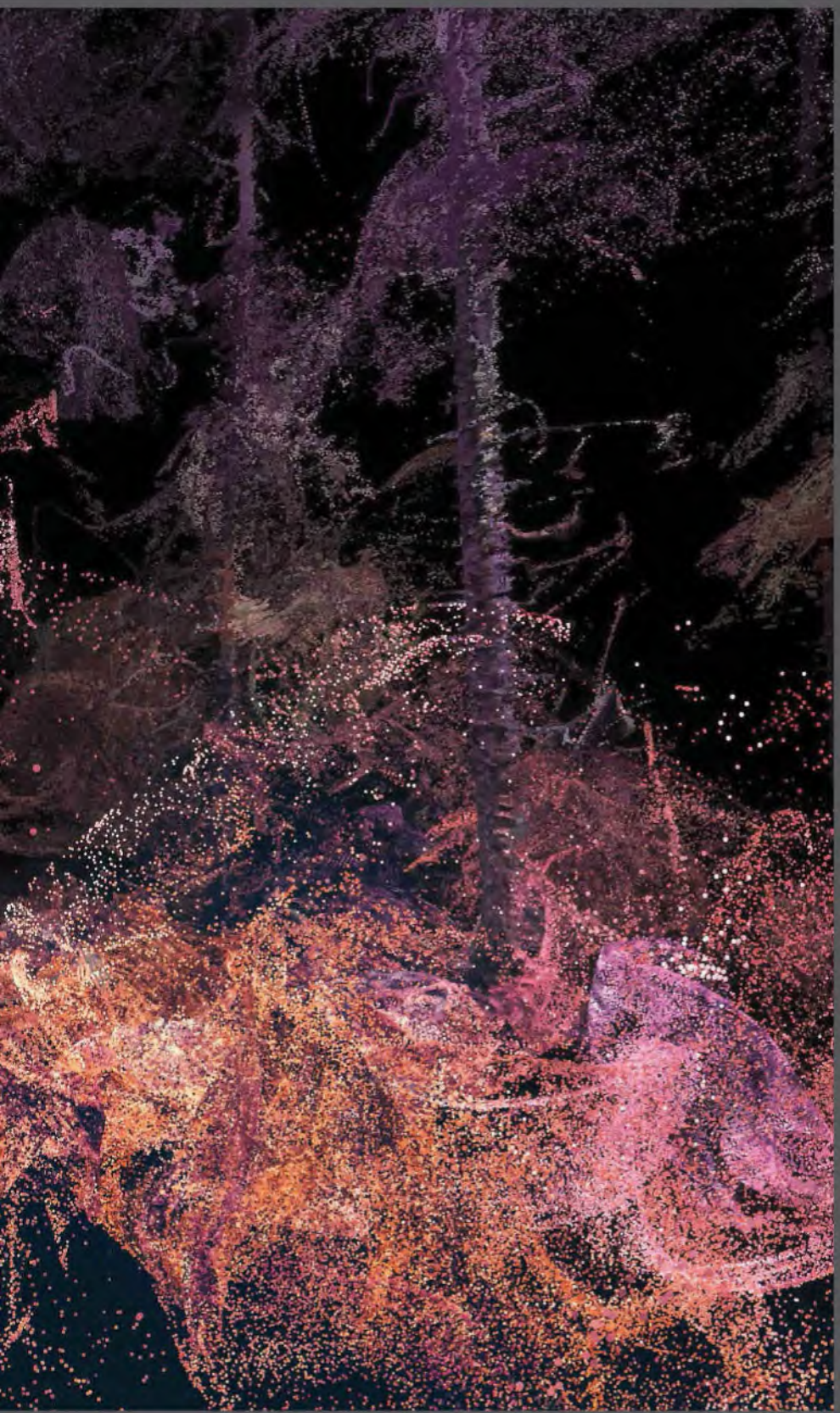
Mind. Full.

Give a gift that satisfies this Christmas

Subscribe and save over 50%

Visit **newscientist.com/8306** or call
0330 333 9470 and quote 8306

NewScientist



Day in the life of a midge

SWIRLING waves of pink and purple engulf me as I soar through the trees, the chatter of the forest punctuated by angry buzzing and clicking noises close to my ears. Is this what it's like to be a midge? No idea, but it is pretty convincing.

Deep in the Grizedale Forest, in the UK's Lake District, a group of us sit on tree stumps wearing moss-covered virtual reality helmets. We're being challenged to consider reality beyond our human limits by seeing the forest through the eyes of a midge, a dragonfly and then a frog. The immersive experience was created by multimedia artists Marshmallow Laser Feast as part of last month's Abandon Normal Devices festival.

As a starting point, the artists captured the forest through a combination of Lidar scanning, 360-degree drone photography and bespoke software. One of the creators, Barney Steel, says they used the midge's ability to detect carbon dioxide in human breath at up to 200 metres as inspiration for a view of the forest that reveals the flow and density of CO_2 in air. "We created a colour palette that imagines higher CO_2 density as a red hue. The trees breathe, sucking in the red and exhaling a cooler palette of oxygen," he adds.

The next stage is to scan insects using micro-CT scanners and electron microscopes, and build 3D models so audiences feel even closer to the animals. Later, the artists plan to explore bats, using microphones in VR helmets to record human sound and turn it into visual data. Liz Else

LUCA MARZIALE

Photograph
Marshmallow Laser Feast

Bottom of the class

Growing evidence suggests that computer technology in schools is of no educational benefit, says **Manfred Spitzer**

WHERE there are effects, there are often side effects. The car is a boon to mobility, but can lead to obesity, injuries, deaths and pollution. Burning fossil fuels may keep economies going, but wrecks the climate in the long run.

In a similar way, the use of information technology in education – from childcare to the classroom to the lecture hall – has side effects. The IT industry and educational policy-makers repeatedly assert that computers are good for learning. But numerous studies have failed to identify any positive impact and have even found negative effects.

The latest is a report by the Organisation for Economic Co-operation and Development. It highlights that education systems investing most in IT saw "no appreciable improvement" in results of exams used to compare the attainment of

15-year-olds internationally – the Programme for International Student Assessment (PISA).

What's more, an earlier study drawing on the PISA results of 250,000 students showed that they performed worse at school if they had a computer in their bedroom. In Israel, researchers found performance declined in elementary and middle schools with computers, and in Romania it has been reported that poorer children whose families received money to buy a computer performed worse in school than those without computers.

Why? Given what we know from experimental psychology and neuroscience, the negative effects of IT on learning are not surprising: the deeper content is processed mentally, the better the learning. IT use seems to result in shallower processing. A study in *Science* found that online

Helping August's child

It's easy to boost the fortunes of the youngest kids in a school year, says **Stephen Gorard**

ARE you an August or a September baby? This is a vexed question for parents; whether their children are born at the end or start of the UK school year can be crucial when it comes to performance at school.

The gap between these groups is substantial throughout primary and early secondary education. Attainment, self-esteem and the chances of being selected for sports teams or university are lower for children born in the UK summer, all other things being equal.

Figures suggest the attainment gap may be widest in the early years. In England, 49 per cent of summer-born children who start school in September having just turned 4 achieve a "good level of development" in their first year, compared with 71 per cent of autumn-born pupils, who are nearly five when they start.

In terms of numbers reaching the "expected" levels of writing, reading and maths, the gap is around 8 per cent from ages 5 to seven and drops very little from ages 7 to 11. By 15 or 16, around 6 per cent more autumn children gain five or more "good" grades at GCSE, in subjects including English and maths, than their summer peers. This suggests the possibility of different futures for many young people based on birth month.

"Attainment, self-esteem and university prospects are lower for the youngest children in a school year"

Such figures explain why the UK government is keen to ensure that all parents of children born from April to August can easily delay the start of school by a year. That sounds sensible, until you realise that this may fail to solve the problem.

Delaying entry by a year (which many parents are reluctant to do), or making pupils repeat a year, have been shown to be ineffective.

So what to do? Altering the date on which pupils enter school won't help; an autumn- or winter-

information is less likely to be encoded in memory than that obtained from books or journals.

Moreover, other studies have shown that laptops in classrooms are linked to poorer performance in tests and assignments, and do not close the achievement gap between socio-economic groups.

Meanwhile, US researchers have concluded that taking notes by hand during a lecture leads to better learning than typing them straight onto a laptop. What's more, a survey of US students found that most are engaged in distracting activities made possible by mobile computing and the wireless internet.

Digital media pose serious risks and side effects in educational settings, causing marked levels of internet addiction, insomnia and inattention, especially when used for non-course-related activities. They also take time away from more valuable learning processes.

In the light of such substantial and converging evidence, it seems appropriate to rethink the investment of public money on ever more IT in the classroom. ■

Manfred Spitzer directs the Transfer Centre for Neuroscience and Learning at the University of Ulm, Germany. His new book, *Cyberkrank!* (Droemer), is out in German this month.

born problem would be no better. Selection, setting and streaming pupils only makes things worse.

There is one solution to much of the problem though: to age-standardise all assessment results. This would mean pupils still sit annual tests or exams at the same time, but with results adjusted for age. These would form the official record for educational decisions by schools, universities, employers, individuals and family.

For the sake of fairness, this is what should be done. ■

Stephen Gorard is a professor of education and public policy at Durham University, UK

ONE MINUTE INTERVIEW

Cleaning up on Everest

Dawa Steven Sherpa is clearing decades' worth of rubbish, human waste and dead bodies from the top of the world

PROFILE

Dawa Steven Sherpa manages Asian Trekking, a company based in Kathmandu founded by his father Ang Tshering Sherpa in 1982. Together, they are leading a push to address Mount Everest's challenging environmental issues

How severe is the problem with rubbish on Mount Everest?

Everest was once known as the world's highest garbage dump, but now the situation is much better. We've been cleaning Mount Everest every year since 2008. I lead Eco Everest Expeditions. So far, we've brought down more than 15 tonnes of garbage left by previous expeditions. From time to time, international cleaning expeditions come to the mountain for a season, but we do it year in, year out. It's a more sustainable approach to the way clean-ups usually work.

We also invite Sherpas from all camps to bring us garbage. We call it cash for trash – they receive $1 per kilo. That way, we're using people and resources that are already present.

Do you only collect litter?

No, we follow the "leave no trace" concept, which includes not leaving any human waste behind. Human waste is one of the most hazardous things on the mountain. Because of the extreme climate, including the cool temperatures and lack of oxygen, the waste doesn't decompose. We need to address this problem, not just because it's icky but because we're drinking water from melted ice, and the waste ultimately flows downstream to villages. We give each Sherpa and climber a toilet bag to take with them above base camp, and it's their responsibility to bring down their own waste. It's working very well, and others have started to adopt that system, too.

Is environmental responsibility enforced on the mountain?

Climbing teams have to pay a $4000 refundable deposit to the government, which is returned only after they receive certification that they brought their garbage back down. But a lot of governmental liaison officers never even make it to the Everest base camps, so how can they certify that a team brings its garbage down? Right now, no one goes up to make sure people are conducting themselves in a responsible way. Instead, we monitor each other. It's in our own interests to self-police.

How is climate change affecting Everest and its surroundings?

The impact of climate change is clear in the high Himalayan region. The rise in temperature here is more than double the global average. Our hometown is at 4000 metres altitude. When my father was a child, Imja Lake, just south of Everest, was like a small hole. Now, that lake has become about 3 kilometres long, more than 100 metres wide and 100 metres deep. That's all from glacial melt. Glacier lakes are increasingly dangerous because they can suddenly burst their banks, killing many people and destroying properties.

We're also seeing bigger and more frequent avalanches. Rocks are emerging from under the ice, resulting in more rockfalls. As the ice melts, human bodies are also starting to appear. Sometimes it's not complete corpses, just remains, and sometimes it's climbers we knew. We've taken five bodies down from the glacier and buried them.

Interview by Rachel Nuwer

ASIAN TREKKING

Past imperfect

Our collective memories of events are often inaccurate. Finding out why could help international relations, say **Henry Roediger** and **James Wertsch**

DURING the Blitz, the UK was pummelled for eight months in a sustained bombing attack by the German Luftwaffe. In London alone, some 20,000 people were killed and a million homes were levelled. The time is remembered as one when plucky Londoners calmly went about their business with resolution and courage, defying Hitler and rallying behind Winston Churchill.

But did it really happen this way? Not according to historian Angus Calder. Drawing on letters, diaries and newspaper accounts from the time, he concluded that Londoners were panicked, exhausted, unable to sleep and in a constant state of mourning for their loved ones. About a quarter of London's population was evacuated to the countryside, Churchill was often booed when he toured bomb sites, and morale was low.

In retrospect, this was the city's "finest hour", but between September 1940 and May 1941, the scene in London was one of turmoil and despair. Today's portrayal therefore represents a collective false memory. Why do those who lived through it remember it as they do and what significance does this hold?

Conflicting accounts

Similar anomalies crop up with other events in the second world war. This year marks the 70th anniversary of the dropping of atomic bombs on Hiroshima and Nagasaki. The collective account in the US is that President Truman and his generals dropped the bombs to end the war, forcing the Japanese to surrender. This is part of the larger American narrative of "how the US won the war". By contrast, the prevailing narrative among Russians is that the bombs were dropped to frighten the Soviet Union into acquiescing to US demands after the war. According to this view, the Japanese were on the verge of surrender, and the bombs were strategically unnecessary in the battle. And, of course, people of other countries have their own memories of the events.

Instances such as these have led us to the study of collective memory in an attempt to understand why stark differences exist between entire countries on "what really happened" and how these views can remain in place for generations.

Collective memory refers to the way in which groups of people remember the past. Such memories can form for a family, a business, a city, or even for a nation. Of course, individuals hold the memories, but studies show that personal memories can converge as individuals discuss events (for instance, eye witnesses talking about a crime) or across generations as events are recounted.

The empirical study of collective memory is a fairly recent endeavour, and researchers turn to many sources – newspaper accounts, interviews and by examining how frequently certain words or phrases occur in large volumes of text. Recently, social scientists have begun to survey large groups of people about their recollections of events, to assess memories more directly. This kind of quantitative research examines recollections of many people, and so provides a more consensual view of collective memory.

We are currently involved in a large online survey of how people in 11 combatant nations recall the second world war. Early results reveal stark differences in which events people in different countries remember, what they know, and how positive their perception is of the events. For example, when asked to list the critical events of the war, battles cited by nearly all Russians are not even mentioned by Russia's allies.

One example is the battle of Kursk, which resulted in more than 1 million casualties, and is widely viewed by historians as a critical turning point in the war.

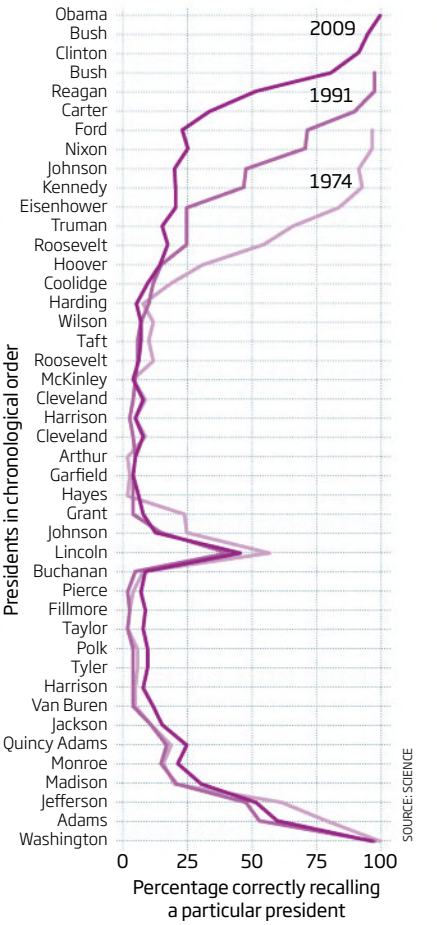
Even within the same group, collective memories are not always static, and can change with new generations. One study has found that almost all people it surveyed in the US viewed the atomic bombs as a major event of the war, but different groups had different perspectives. Those who had lived through the war saw the bombings in a positive light (rating them about an 8 on a 10-point scale), whereas college students viewed the events rather negatively (about a 3). It seems that younger people, in line with

PROFILE
Henry Roediger is a psychologist and **James Wertsch** is an anthropologist, both at Washington University in St Louis, Missouri. Wertsch is the author of *Voices of Collective Remembering*. Roediger is co-author of *Make it Stick: The science of successful learning*

PRESS ASSOCIATION IMAGES

Collective forgetting

Most Americans remember only recent and notable presidents in the correct order



SOURCE: SCIENCE

modern textbooks, are more likely to take into account the horrific deaths and radiation poisoning caused by the bombs, rather than thinking the bombs ended the war and resulted in the troops returning.

Quantitative research into collective memory can help us understand not just what is collectively remembered, but also what is being forgotten – and how fast. One US study asked people to recall as many presidents as they could, in 5 minutes, putting them in chronological order wherever possible. The experiment was conducted in 1974, 1991 and 2009. Not surprisingly, almost everyone knows the current president, but recall of the most recent presidents drops off steadily (see chart, above right). People are consistently able to recall Washington and the earliest presidents, Abraham Lincoln and those around him and then those closest to present day. The results of all except the most recent presidents were similar across 35 years.

"Collective memory shapes recall of the past, but also sets a course for the future"

People have a picture of the Blitz as a time of courage and defiance. In reality, morale was low

We also scored people's ability to remember the names of presidents irrespective of order. This allowed us to measure how quickly leaders had been forgotten since the second world war. We found that presidents Kennedy and Nixon were being forgotten slowly, but Truman, Eisenhower, Johnson and Ford were being forgotten more rapidly. In another 40 years, they may be as poorly recalled as 19th century figures Zachary Taylor or Franklin Pierce.

Collective memory shapes not only varying recollections of the past, but also sets a course for future action. When US politicians were debating the invasion of Iraq in 2002 and 2003, proponents looked back to the second world war to justify invasion. They argued that stopping Saddam Hussein would be akin to intercepting a new Hitler before he could invade his neighbours. Those on the other side of the debate likened Iraq to Vietnam. They argued that the US was getting involved in a local dispute that posed no direct threat to the country's interests, and which was likely to involve a protracted and costly war.

If we can understand what the collective memory is, and why it is held, we will understand the reasoning and motivations behind it (even if we do not agree with them). And that understanding can help us resolve conflicts and better predict what actions a group or country might take in the future. ■


NOW
WITH LESS
NUTRITION!
REDUCED
9715 0518 9871 0293 9004 2006
BEST BEFORE: 1950
BROCCOLI FLORETS

Best before?

Is the way we produce and process food making it less nourishing, asks Chloe Lambert

VEGAN, low carb, Palaeo, 5:2. The quest for the healthiest diet shows no sign of abating. We now know more than ever about what food does to the body and the importance of antioxidants, healthy fats and a low glycaemic index.

But what if, all the while, our food has been getting less nutritious? What if modern intensive farming methods – many of which solved malnutrition problems when they were first introduced – have affected the mineral and vitamin content of what we eat? Could having a constant supply of varied produce be compromising its goodness?

Some of the most eye-catching work in this area has come from Donald Davis, a now-retired biochemist at the University of Texas. In 2011, he compared the nutrients in US crops from 1950 and 2009, and found notable declines in five nutrients in various fruits, including tomatoes, eggplants and squash. For example, there was a 43 per cent drop in iron and a 12 per cent decline in calcium. This was in line with his 1999 study – mainly of vegetables – which found a 15 per cent drop in vitamin C and a 38 per cent fall in vitamin B2 (see table, page 36).

Fruit and vegetables grown in the UK have shown similar depletions. A 1997 comparison of data from the 1930s and 1980s found that calcium in fresh vegetables appeared to drop by 19 per cent, and iron by 22 per cent. A reanalysis of the data in 2005 concluded that 1980s vegetables had less copper, magnesium and sodium, and fruit less copper, iron and potassium.

Davis and others blame agricultural practices that emphasise quantity over quality. High-yielding crops produce more food, more rapidly, but they can't make or absorb nutrients at the same pace, so the nutrition is diluted. "It's like taking a glass of orange juice and adding an equal amount of water to it. If you do that, the concentration of nutrients that was in the original juice is dropped by half," says Davis.

But the idea that modern agriculture produces crops that are less nourishing remains controversial, and "then and now" nutritional comparisons have been much criticised. The differences found may be down to older, less accurate methods of assessing nutrition, and nutrient levels can vary widely according to the variety of plant, the year of harvest and the time of harvest.

Other studies have sought to get round this by comparing old and new varieties of a crop grown side by side. In 2011, researchers at the US Department of Agriculture measured the concentrations of 11 minerals in 14 commercial varieties, or cultivars, of broccoli launched between 1950 and 2004.

They found no clear relationship between mineral levels and the year that a particular cultivar was released, but there was evidence of a dilution effect: bigger broccoli heads favoured today had lower levels of some minerals relative to a 1950 variety called Waltham 29 (see table, page 36). But, as the study also noted, Waltham 29 is less tough than modern cultivars and so would be unlikely to succeed if grown in the same way.

And there lies the rub. Even if the arrival of intensive agriculture has meant that our vegetables contain slightly less nutrients than those our grandparents ate, it has also led to a huge increase in food supply, which has undoubtedly had a positive effect on our diet and health.

"Some evidence suggests that some nutrients have fallen, particularly trace elements such as copper in vegetables," says Paul Finglas, who compiles nutritional data on UK food at the Institute of Food Research in Norwich. "Foods are now bred for yield, and not necessarily nutritional composition. ›

GETTY IMAGES

What's really on your plate

How have modern farming methods affected the nutrients in common foods?

Beef

Beef from cattle reared outdoors on grass is less fatty and contains more omega-3 fatty acids than cattle reared indoors and fed mainly grain. However, consumers preferred the taste of latter, according to a 2014 study.

Pasta

Today's pasta might be less nutritious thanks to modern, fast-growing wheat varieties introduced in the 1960s. Levels of zinc, iron and magnesium remained constant in wheat grain from 1865 to the mid-1960s, then decreased significantly as yields shot up.

Carrots

Carrots from the 1940s contained less than half the vitamin A levels of carrots grown in the US 50 years later. The reason? A preference for more orangey carrots. The colour comes mainly from the pigment beta-carotene, which the body can use to make vitamin A.

Milk

Milk from cows reared the old-fashioned way – mainly feeding on grass outdoors – has a better nutritional profile of proteins, fatty acids and antioxidants than milk from cows reared indoors and fed intensively.

Spinach

Spinach is a good source of iron, but its iron content was once thought to be 10 times higher. That was the result of a historical error that may have been perpetuated by the spinach-derived superpowers of the cartoon character Popeye. There is no clear data about whether the iron content of spinach is changing due to modern agriculture, although fluorescent lighting in shops does boost its vitamin levels.

Eggs

Eggs have been the subject of health scares over cholesterol, but now they are promoted as a health food. A 2012 study found that UK eggs are getting more nutritious, with lower fat and cholesterol compared to eggs from 1989 – probably because of smaller yolk sizes. They also contained more selenium and vitamin D than in the past, thanks to improved hen feed.

But I don't think that is a problem, because we eat a wider range of foods today than we did 10 years ago, let alone 40 years ago".

Eric Decker, professor of food science at the University of Massachusetts in Amherst, agrees. If nutrients are declining, the losses aren't significant enough to warrant any concerns over health, he says. "Over the last century, lifespans have got longer, people are bigger and stronger, and a lot of that has to do with the food supply being better."

Even Davis agrees that any differences in nutrient levels are relatively small. "Despite their declines, fruit and vegetables are still our richest source of many nutrients, and you can make up for it by eating more," he says. "But we know that even in developed countries, many people don't get the recommended amounts of some of the nutrients we are talking about – such as iron, magnesium, calcium. They aren't overt deficiencies in the usual sense, but they increase susceptibility to lots of different problems."

Other crops are also getting subtly less nutritious. The introduction of semi-dwarf, higher-yielding varieties of wheat in the green revolution of the 1960s means that modern crops contain lower levels of iron and zinc than old-fashioned varieties.

And as farmers strain to feed ever more mouths in the face of environmental change, the problem may become worse. Last year, researchers at Harvard University warned that crops grown in the future will have significantly less zinc and iron, due to rising levels of carbon dioxide from fossil fuel use.

"Rising carbon dioxide levels will mean future crops are less nutritious"

The team grew 41 different types of grains and legumes, including wheat, rice, maize, soybeans and field peas, under CO_2 levels crops are likely to experience 40 to 60 years from now. They found that under these conditions, wheat had 9 per cent less zinc, 5 per cent less iron and 6 per cent less protein than a crop grown at today's CO_2 levels. Zinc and iron – but not protein – were also lower in legumes grown under elevated CO_2.

If the food we grow has changed subtly over time, what difference, if any, does the journey from field to plate make? Even an apparently natural product like a lettuce or tomato will have been manipulated to some degree before we buy it. Does it matter, nutritionally?

Fruit and vegetables in supermarkets might look shiny and fresh, but often they were picked several days earlier. Some nutrients, particularly vitamin C and folic acid, begin to oxidise as soon as picking happens, but manufacturers use chilling and packaging techniques to minimise the resulting losses. "Lots of these reactions are driven by enzymes, and if you want to slow an enzyme reaction right down you chill it. That's why the cool chain is so important," says Carol Wagstaff, who studies crop quality at the University of Reading, UK.

That said, if you are choosing between organic leeks from a distant country or locally grown, non-organic ones, always opt for home-grown, she says. "From a nutritional standpoint, go for the shortest possible supply chain rather than the production method."

A 2003 study evaluated the nutritional content of broccoli kept in conditions that simulated commercial transport and distribution: film-wrapped and stored for seven days at 1 °C, followed by three days at 15 °C to replicate a retail environment. By the end, the broccoli had lost between 71 and 80 per cent of its glucosinolates – sulphur-containing compounds shown to have cancer-fighting properties – and around 60 per cent of its flavonoid antioxidants.

Many kinds of mass-produced fruit and veg – most famously tomatoes – are picked unripe so that they bruise less easily during transit. They are then sprayed with ethylene to ripen them. Some studies suggest that tomatoes harvested early have lower antioxidant activity and less flavour. "If a fruit is left on a plant until the end of its life cycle, it's able to recycle all the energy from the plant," says Wagstaff. "If you pick it early you truncate that process and get less sugars into the fruit, which are needed to bind the nutrients."

Supermarket tomatoes are often labelled as "vine-ripened", but that doesn't always mean what you hope, she says. "It may be ripened on the vine but the vine may not have been attached to the plant." However, Wagstaff stresses that the downsides of early picking are small and an unavoidable consequence of consumer demand. "If you pick a tomato that you have grown at home, it tastes fabulous because it's absolutely ready to eat," she says. "But there's no way you could do that at a commercial level because of the bruising that would occur if ripe fruits were transported through a typical supply chain. There has to be a compromise somewhere."

Another complication is that each method of shipping and storing foods has different ›

CLOCKWISE FROM TOP LEFT: FRANK BEANY; FLOORTJE; KAREN STRAUSS; TS PHOTOGRAPHY; URSULA ALTER; RACHEL HUSBAND/GETTY

The bellyache over modern bread

Humans have been making bread for 10,000 years, but the way we do it has changed dramatically in the last half-century. In 1961, a new method of mass-producing bread was devised at the Chorleywood laboratories, just north of London. It used extra yeasts, additives called processing aids and machinery to slash fermentation times, so a loaf could be made in just a few hours. Around 80 per cent of bread consumed in the UK is now made this way, and the Chorleywood process is used to some extent in many other countries.

But there are concerns that such methods have altered the digestibility of bread, and this may explain why many people with irritable bowel syndrome name bread as a trigger. For a significant subset of those with IBS, the condition is thought to be linked to gut bacteria reacting to fermentable foods, causing gas and bloating.

Last year, Jeremy Sanderson at King's College London and colleagues compared the effects of fast and slow-fermented breads on gut microbiota from donors with IBS and those free from it. They found that sourdough bread – which is left to rise for several hours using its natural yeasts – produced "significantly lower cumulative gas" in the IBS donors' microbiota than fast-fermented bread. The theory is that if bread is left to ferment for longer, its carbohydrates will reach the gut in a predigested state and gut bacteria won't react so much. "If you under-ferment bread and add a lot of yeast, it's hardly surprising this will set up problems for people who have a problem with fermentation in their gut," says Sanderson.

Slow-fermented breads may benefit other groups too: sourdough produces a lower glucose response in the body than other breads. What's not yet clear is whether eating slow-fermented breads would lead to a general improvement in the gut flora of healthy people. "That's difficult, but it's a reasonable hypothesis," says Sanderson. "After all, bread-making probably evolved to match what the gut could cope with."

On the breadline: has mass production made a staple food a no-no for some?

MICHAEL ROSENFELD/GETTY

The great organic debate

If modern, high-intensity farming is causing food to lose some of its goodness, could organic food offer an alternative?

It's a controversial question. Antioxidant levels are higher in organically grown plants, according to a meta-analysis of existing studies published last year. However, in 2012 researchers at Stanford University in California found no strong evidence that organic foods are more nutritious.

"In general, for minerals, the differences [between organic and inorganic] are pretty small," says biochemist Donald Davis. One reason for the nutrient declines seen in some of today's vegetables is down to breeding – making broccoli heads larger, for example – and organic growers tend to plant the same varieties as non-organic growers, he says.

Another complication is that it is difficult to make a direct comparison of organic and non-organic crops. "You have to take enough samples to grow on a very controlled patch, and expose them to exactly the same treatment," says Paul Finglas of the UK's Institute of Food Research in Norwich. "There may well be some evidence that some organic foods are different – such as in vitamin C – but it's not going to make a big nutritional impact."

Things look better for organic buyers when it comes to milk. Recent UK and US studies found that organic milk from cows reared outdoors had higher amounts of antioxidants and omega-3s. The difference is down to diet. "Cattle on organic farms are provided much more access to pasture and fed a much higher proportion of forage-based feeds," says Charles Benbrook, who showed in 2013 that organic milk produced in the US contains a healthier ratio of omega-3 to omega-6 fatty acids than non-organic milk (see "Fat lot of good", opposite). "Grass and legume forages are the building blocks for omega-3 fatty acids, while corn – which plays an important role on conventional farms – is the basis for omega-6."

A subtle colour change means that some carrots give us more vitamin A

TESSA BUNNEY/MILLENNIUM IMAGES, UK RIGHT: KIM REINICK/SHUTTERSTOCK

Unsavoury dip

How does fruit and veg from 1950 compare with those grown half a century later? A US survey of 43 crops found a decline in six key nutrients

Vitamin C ↓ **15%**

Iron ↓ **15%**

Vitamin B2 ↓ **38%**

Calcium ↓ **16%**

Protein ↓ **6%**

Phosphorus ↓ **9%**

Heads you lose

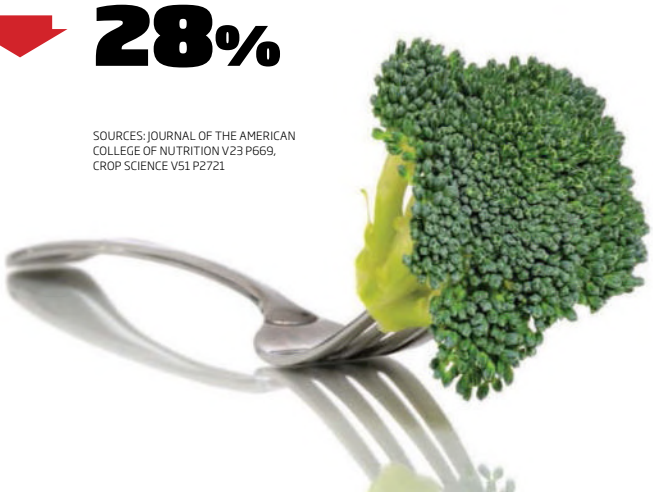
Is broccoli as good for us as it used to be? A 2004 variety, Green Magic, contains significantly lower levels of mineral nutrients than one called Waltham 29, launched in 1950

Iron ↓ **18%**

Magnesium ↓ **30%**

Zinc ↓ **28%**

SOURCES: JOURNAL OF THE AMERICAN COLLEGE OF NUTRITION V23 P669, CROP SCIENCE V51 P2721



effects on the compounds they contain. Vitamin C, for example, breaks down in the dark, whereas glucosinolates – found in vegetables like broccoli and cabbage – deplete in the light. "That's one of the problems with horticulture," says Wagstaff. "By its very nature you have an enormous diversity of genera and species. In an ideal world, each one would have a tailored supply chain."

Favourable light

In the case of spinach, it that seems fluorescent lighting in supermarkets can be beneficial. A 2010 study found that spinach leaves stored in simulated retail conditions had higher levels of vitamins C, E, K and folic acid. After nine days of continuous light exposure, folic acid increased between 84 and 100 per cent. In spinach stored in darkness, nutrient levels stayed the same or fell.

They may not be fashionable, but frozen fruit and vegetables are often nutritionally better than fresh, says Wagstaff. "Frozen veg is extremely good in terms of nutritional value because it really has been in suspended animation from the point of harvest," she says. "You can leave it on the plant longer, so it's at a better ripening stage when it's picked. "

Peas can lose half of their vitamin C in the first 48 hours after harvesting, but if frozen within 2 hours of picking they retain it. "Frozen peas are much more nutritious than peas you buy ready to shell," says Catherine Collins, principal dietician at St George's Hospital in London. What's more, frozen foods often have fewer additives. "Freezing is a preservative," she says.

Similarly, processing has become a maligned word in the context of food, but there are some cases where it enhances a food's health benefits. In fact, you arguably get more benefits from processed tomatoes, such as in purees, sauces or ready chopped in cans, than fresh.

Processed tomatoes tend to be harvested at a riper stage. In addition, lycopene – a compound tomatoes are rich in, and which has been shown to protect against cancer – is much more readily absorbed by humans from tomato paste than fresh tomatoes. "The more processed a tomato is, the more lycopene is available," says Collins. "Processed tomatoes are often very concentrated, so you're actually getting a greater quantity than you would use if you made your own sauce." However, she adds that the heating used in processing destroys vitamin C.

Processed tomatoes have been on sale for more than a century – Heinz ketchup was launched in 1876 – but a much more recent trend is the sale of "fresh-cut" fruit and vegetables – peeled potatoes, ready chopped carrots and bagged salads. One in five adults in the UK regularly buy fruit and vegetables in this form every week, according to market research firm Mintel. Surely this cutting and peeling speeds up the degradation of nutrients?

Although salad leaves that have been picked and stored for several days before being eaten are a bit less nutritious than a freshly harvested lettuce, chilling and using packaging to reduce oxygen exposure may slow the nutrient loss. And any loss of nutrients must be weighed against the fact that these products may encourage people to eat better overall.

"There is a chance that ready prepared vegetables may have a lower content of some vitamins," says Judy Buttriss, director general of the British Nutrition Foundation in London. "But if their availability means that such vegetables are consumed in greater quantities, then the net effect is beneficial."

The bottom line is that although aspects of today's food production, processing and storage might make what we eat a bit less nutritious, they are also making foods more available – and this is far more important. The majority of us consume far less fruit and vegetables than we ought to. We eat too much fat, sugar and salt and not enough oily fish.

"The most important thing you can do is eat more fruits, vegetables and wholegrains, and cut down on highly refined, human-made foods, vegetable oils and added sugars," says Davis. "If you're worrying about nutrient losses from cooking or whether your food is straight from the farm – those differences are minor compared to the differences you'd get from eating unprocessed foods." ■

Chloe Lambert is a freelance writer based in London, UK. For references cited see our online article at http://bit.ly/FactoryFood

Fat lot of good

Nutritional deficiencies shouldn't be an issue for consumers in rich countries, but one area of concern is the low intake of omega-3s. These essential fatty acids, particularly long-chain omega-3s found in oily fish and shellfish, are vital for growth and development.

The average intake among adults in the US and UK falls far short of the recommended amount, largely due to the fact that many people eat little or no seafood. "Omega-3 is probably one nutrient that [Western] people have a deficiency in – at least, they're not at the optimum level," says Eric Decker, a food scientist at the University of Massachusetts.

Meanwhile, people are consuming more omega-6 acids, found in vegetable oils. These are important too, but in excess amounts they can trigger the body's inflammatory response.

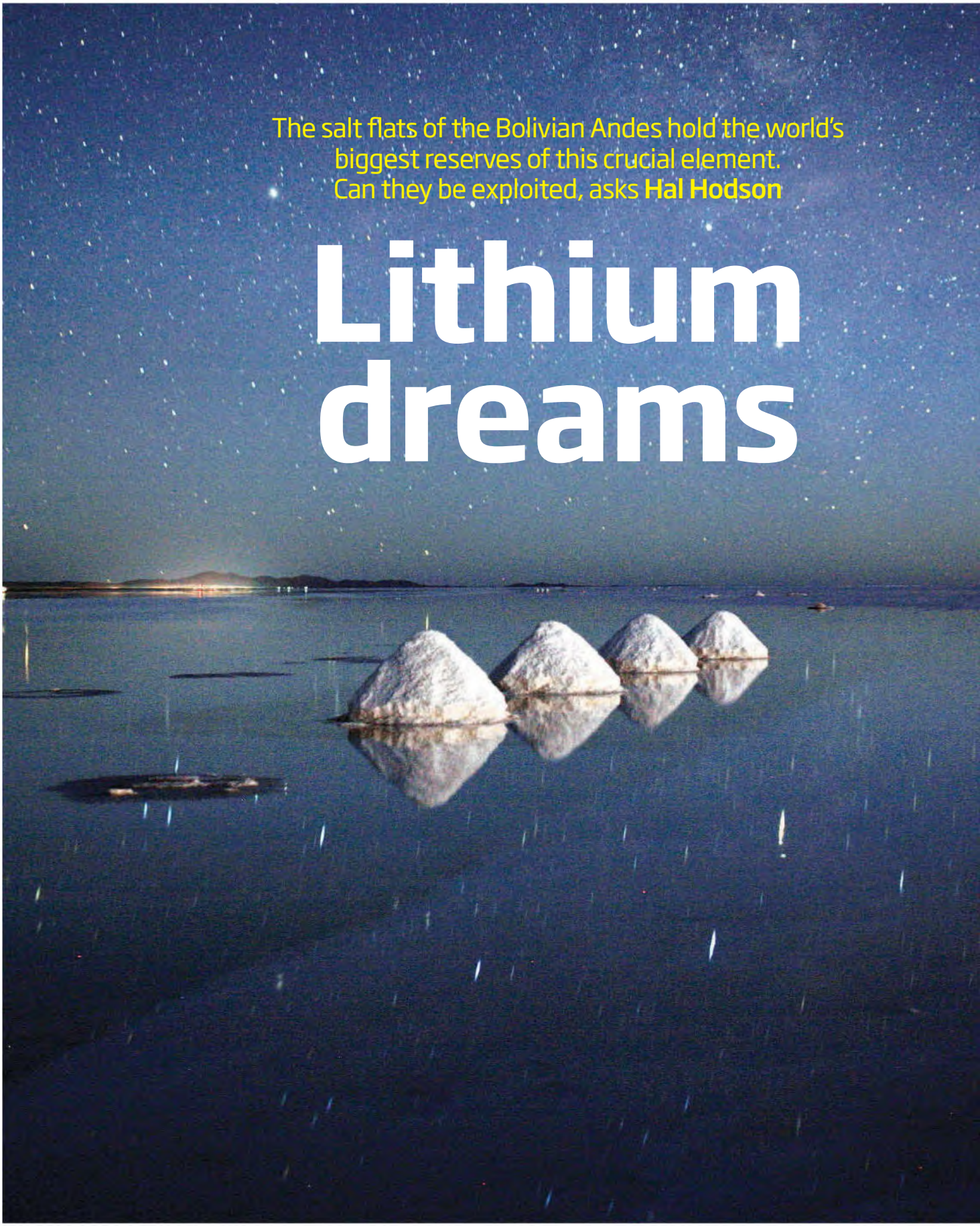
What's worrying some is that changes in farming methods are making some foods lower in omega-3s and higher in omega-6s. This has been shown most clearly in fish. Half of all fish consumed globally now come from aquaculture, and farmed fish have a different nutritional profile to wild-caught varieties. Wild salmon, for example, is an excellent source of omega-3s, because it feeds on smaller fish that have eaten omega-3 rich algae. But farmed fish are increasingly fed vegetable oil, boosting their omega-6 levels.

Last year, a study of salmon sold in the UK found that farmed salmon had twice the amount of fat as wild salmon, a lower proportion of omega-3s and significantly more omega-6 fatty acids – although the authors stress that farmed salmon is still a good source of omega-3s. Similar trends have been seen in organic and non-organic milk and beef (see "What's really on your plate", page 36), though these contain far less omega-3 than fish.

Fortification is one way to tackle this problem – hence the array of omega-3 enriched products, such as juice and yogurt, now on the market.

The salt flats of the Bolivian Andes hold the world's biggest reserves of this crucial element. Can they be exploited, asks **Hal Hodson**

Lithium dreams



KARLA GACHET/PANOS

The Salar de Uyuni has more lithium than anywhere else

IN THE middle of the Salar de Uyuni, a fleck of volcanic rock called Isla del Pescado rises out of the salt. Its peaks are furred with 3-metre-high cacti, though plants here grow just a centimetre per year. Salt stretches out in every direction as far as the eye can see. Other than dark traces from the tyres of tourist 4x4s, only sunset and sunrise disrupt the white of the salt flats, tinting it pink and green.

Concentrated in layers of brine beneath this expanse, 3800 metres up in the Bolivian Andes, is more lithium than anywhere else on the planet. Until 20 years ago, this lightest of all metals had mundane and low-key uses: as a glaze for heatproof cookware, for example, or a grease to lubricate hot moving motor parts. But that's all changed with the advent of lithium-ion batteries. Portable, rechargeable and capable of storing enough electricity to run the supercomputers in our smartphones for hours on end, the ambition is that they should power our cars and our home electricity supply as well (*New Scientist*, 25 July, p 20).

The salt flats of Bolivia and neighbouring Chile are home to more than 40 per cent of the world's lithium. Although Chile's extraction industry is well-developed, Bolivia is only now starting to tap its stores in the Salar de Uyuni. I've travelled here with a group of architectural researchers called Unknown Fields to find out how the lithium industry is set to handle rising global demand, and whether the pristine landscapes that harbour this treasure can be preserved.

The Salar de Uyuni is a lesson in sensory deprivation. Warped salt hexagons rush past our car window, blurring into a white cloth that stretches towards mountains on the horizon. Yet geologically speaking it's a young landscape. "If we happened to be living 2 billion years ago, there would have been very little in the way of lithium-rich rocks at the surface," says Stephen Kesler, a geologist at the University of Michigan in Ann Arbor. "They are a relatively recent phenomenon."

We're driving on volcano vomit, scum in an Andean rock bathtub. When volcanoes spewed magma from deep within Earth's mantle onto the surface here 25 million years ago, lithium came with it. Some 24 million years later, it started to rain. As the Salar de Uyuni is part of a natural basin with no drainage channels (see diagram, page 40), a 51,000-square-kilometre mega-lake known as Tauca formed, stretching the full length of Bolivia from north to south. Altitude and a dry climate combined to slowly evaporate its waters, leaving layers of mud and concentrated lithium brine leached from the volcanic rocks below.

Such salt flats aren't the sole sources of lithium – only this August, Tesla Motors signed a contract to take up to 50,000 tonnes of lithium hydroxide every year from clays in northern Mexico for use in its electric cars. Mines in Greenbushes in western Australia were previously the main source of mined lithium, says David Merriman, an analyst with mineral consulting firm Roskill Information Services in London.

But sucking lithium out of brine at a salt flat is cheaper and more energy-efficient than digging it out of rock. Only a few spots on the planet have the right conditions to produce concentrations that match those in the Andes: small pockets of the western US , for example, and high on the Tibetan plateau. But nowhere matches the scale of the Andean deposits.

The lithium in the Salar de Atacama in neighbouring Chile has been exploited for more than 30 years, but Bolivia's state mining company, COMIBOL, has only just started tapping the Uyuni deposits at Llipi on the southern edge of the salar. A river there trickles beneath the flats, flushing lithium south to create a high concentration right under Llipi.

Plants in the desert

The lithium plant here looks a little ramshackle from the outside, and guards take names and passports as we file in. Political factors have complicated Bolivia's relationship with lithium. The country has long wanted to control the terms of extraction itself, and remains opposed to the intrusion of multinational corporations. As we travel from the de facto capital, La Paz, to Uyuni, we hear the same aspirational chant for the country's lithium industry over and over: "By Bolivia, for Bolivia, in Bolivia."

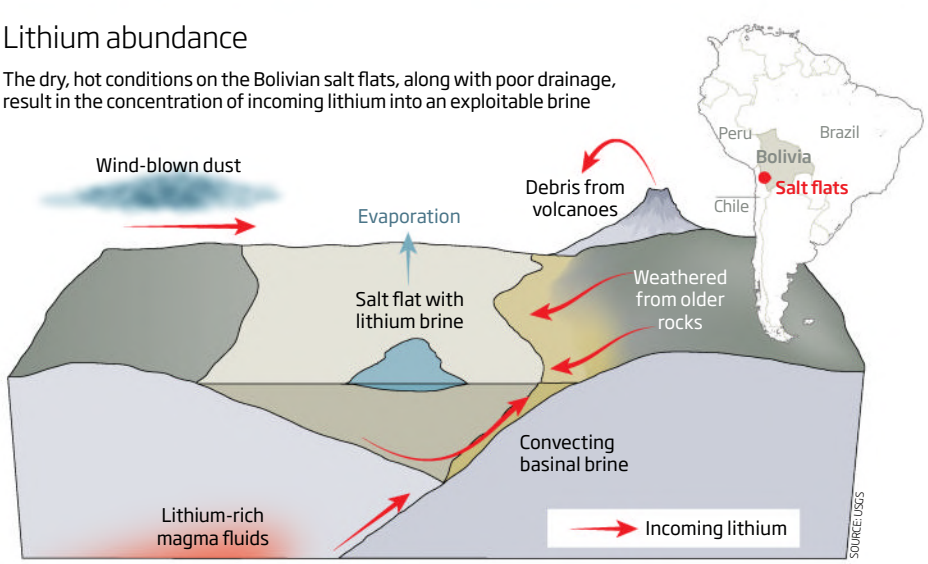
Its lithium might already be on the global market, were it not for the efforts of Francisco Quisbert, known locally as Comrade Lithium. His weathered hands clasped behind his back, Quisbert tells us how, in the early 1990s, he discovered that a Canadian company called Lithium Corporation (LITCO) had quietly acquired exclusive rights to extract minerals from the whole salar. "The LITCO contract had no local benefit," Quisbert says. "We blocked roads and trains to block the project." LITCO pulled out of Bolivia, and the country's lithium lay dormant for two more decades.

But it's not just politics that holds things up. Lithium, the third element in the periodic table, is one of only a few that were ›

High concentrations of lithium in the Andean salars are a result of their unique geology

Lithium abundance

The dry, hot conditions on the Bolivian salt flats, along with poor drainage, result in the concentration of incoming lithium into an exploitable brine



synthesised directly in the big bang, congealing quickly out of a hot soup of protons and neutrons. Much of it immediately decayed back into helium. On Earth, lithium is so reactive that it is only found bound together with other elements. Under the Salar de Uyuni, lithium atoms mostly combine with sulphur, a challenging compound to break apart.

And there's more. Because it receives more rain than the Salar de Atacama, Uyuni's lithium brines are more dilute, with higher levels of other salts. "The main problem is grade: the percentage of lithium in any block of material or gallon of brine," says Kesler. Uyuni is also relatively rich in magnesium, he says – a particularly troublesome element to get rid of.

Lithium extraction starts on the salt flats, where giant excavated pools stretch to the horizon. Each one is a different colour, dictated by its salt content. Solar radiation constantly evaporates water molecules off the pool's surface into the thirsty air, leaving less behind for salts to stay dissolved in. Sodium chloride, or common table salt, is the first to feel the squeeze, dropping out of solution in the biggest sky-blue pools. Magnesium, potassium and calcium all precipitate out in sequence, their pools varying in colour from canary yellow to pink-white.

It takes about 18 months for water to make its way to the lithium pool at the end of the chain, coloured a dull green-brown like toxic tea. At its edge is a solid white precipitate of lithium sulphate, the first dry form this lithium has seen for thousands of years. I reach down to crack off a small crystal and place it on my tongue. It tastes vaguely sweet for a minute, then turns bitter.

Keeping the pace

A 10-minute drive inland from the flats brings us to Llipi, where researchers are investigating ways to free lithium from its chemical impurities, says COMIBOL chemist Marco Antonio Limachi. They have found 11 new ways of doing this, he says, but the details are under patent. What they have found is put into practice in the factory next door. Here, a pile of 50-kilogram sacks with "Li_2CO_3" written on them take up one wall. Pressure vessels hiss and white powder coats every surface. Raul Martinez of COMIBOL, who shows us around, tells us not to take any photos. The basic chemical process involves adding calcium carbonate to the lithium sulphate brine in steps, separating liquid from solid every time, and repeating until the lithium can be persuaded to abandon the sulphate and bind to carbonate ions instead.

Llipi's lithium output is currently tiny, but Martinez says made-in-Bolivia lithium carbonate has already been used to make an

array of batteries that back up a power plant in Cochabamba, one of Bolivia's biggest cities. COMIBOL says the batteries were made at a pilot factory in Potosí, Bolivia's mining capital, pointed out as testament to the country's nascent lithium industry.

Across the border in Chile, lithium extraction has been ramping up for years. Two main mining companies – Rockwood Lithium,

"I place a small crystal on my tongue. It tastes sweet for a minute, then bitter"

a subsidiary of US chemical giant Albemarle, and Chilean mining company SQM – operate in the Salar de Atacama. Whereas rain dissolves and flattens Uyuni's salt every year, the Atacama is the driest place on Earth outside the poles. It sees rain so rarely that its salt surface is dirty, cracked and warped, contorted into sculptures like dry lips seen under a magnifying glass. It's uglier than Uyuni, but its lithium brine is more concentrated.

At Rockwood, the evaporation pools look like psychedelic patchwork, bigger and more regularly laid out than those at the Llipi plant. As at Llipi, colours ramp up from baby blue to canary yellow. The Atacama's geology is different, though, so lithium binds to chloride ions, which are easier to remove.

Rockwood's final product is a glaring yellow pool containing 6 per cent lithium, the highest possible concentration before the solution saturates and the lithium chloride starts to form solid clumps. Tanker trucks suck up the liquid and drive it to Rockwood's processing facility, where some 28,000 tonnes of lithium carbonate are produced every year.

Elsewhere on the salar, rival SQM pulls up 10 times more brine than Rockwood, with the principal aim of producing potassium chloride fertiliser. Lithium emerges from the process as a by-product, but its output still surpasses Rockwood's by a few thousand tonnes every year. The scale of its operation is highlighted by the size of SQM's plot: whereas at Rockwood, our group could wander around on foot, it takes 20 minutes just to drive from the borders of the SQM site into the plant.

Most of the lithium that both sites produce ends up on ships in the Pacific port of Antofagasta, 350 kilometres to the east, bound for major industrial ports such as Rotterdam in the Netherlands or Guangzhou in China. It is China that dominates the processing of these raw lithium sources into the batteries that increasingly power the world.

Although brine extraction is more environmentally friendly than hard-rock mining, it does have costs, says environmental and human-rights lawyer Alonso Barros. Barros used to work as a mediator between mining companies and the indigenous communities that have lived in and around the Salar de Atacama for centuries. Conflict between the two, perhaps inevitably in a desert climate, mostly comes down to water.

The Atacama may be dry, but water flows down under the salt flat from the mountains and volcanoes that surround it, feeding wells that support farmers and towns on its edge. When brine is sucked out to make lithium, it leaves a hole in the water table that higher water rushes to fill, depleting the wells. Barros says mining companies withdraw brine from beneath the Salar de Atacama at a faster rate than it is naturally replenished, gradually depleting the surrounding water table.

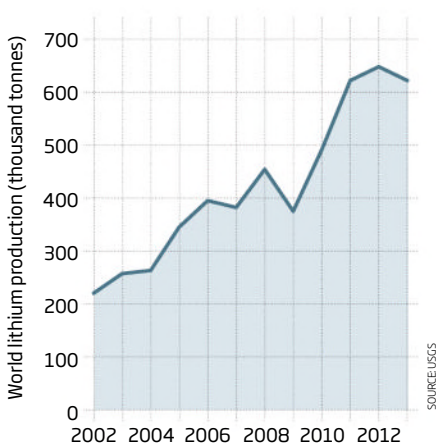
Although officials and engineers at the Llipi plant claim the current water extraction rate is well within the region's ability to replace it, the latest plans involve expanding the current lithium production sevenfold, matching the scale of Chile's Rockwood and SQM.

PHOTOS BY KATE DAVIES, LIAM YOUNG/UNKNOWN FIELDS AND HAL HODSON

Colourful pools of lithium brine contrast with the whiteness of the salar

Charging ahead

The growing popularity of lithium-ion batteries has seen demand for the element skyrocket



Just a week after our visit in August, Bolivian president Evo Morales signed a contract with a German engineering company to help with the construction of an industrial-scale lithium plant on the Salar de Uyuni. Morales announced plans to spend $925 million on the project by 2019, maintaining Bolivia's long-standing policy of non-reliance on foreign loans. Ultimately, COMIBOL envisions full-scale lithium extraction covering a maximum of 5 per cent of the salar's surface, confined to a southern portion largely unseen by tourists

Even with investment on that scale, Bolivia still has a long road ahead if it wants to catch up with established players in the lithium market. "If they're wanting to compete in a global market, they have a hell of a long way to go technology-wise," says Merriman. "It's going to be incredibly difficult for them."

Getting its lithium onto the global market would undoubtedly benefit the Bolivian economy as a whole, generating jobs and the promise of a better life for its citizens. The question of possible environmental costs remains open – the same tense story that is already playing out over Bolivia's other rich resource, gas, and its pristine swathes of Amazon forest – but opposition to the burgeoning industry will take time to develop.

As our hunger for the latest slick device continues to drive demand for this most prized of elements, those who live around the salt flats may see their environment change dramatically. But for now at least the gleaming white salt on the harsh landscape of the Salar de Uyuni still stretches to the horizon undisturbed. ■

Hal Hodson is a reporter for *New Scientist* based in London

RED ALERT

Our tried and tested way of sussing cosmic distance is struggling to keep up with the latest generation of galaxy surveys, says cosmologist **Andrew Pontzen**

"ONE last time," says Father Ted, patiently holding up a tiny model cow to a clearly baffled Father Dougal. "These are small. But the ones out there are far away."

Astronomers don't have to be fans of the classic UK sitcom *Father Ted* to recognise they have a similar problem with perspective – one that is becoming ever more acute as we look further and deeper into the cosmos. Over the coming decade, a new generation of telescopes will be taking petabytes of data to map out the night sky in unprecedented detail. This comprehensive three-dimensional picture of what's where will help us better understand the forces that have shaped the universe.

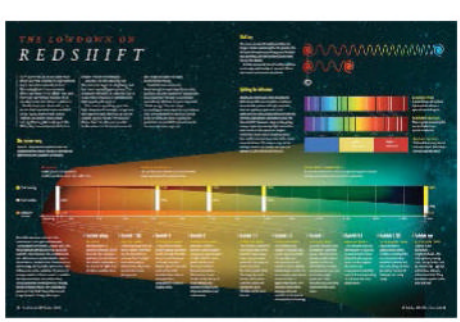
But creating a 3D picture from a telescope's 2D images means accurately gauging distance – and unlike cows, galaxies vary enormously in shape and size. Is this one small, or just far away? Big, or close by? In this modern era of astronomical precision, it's rapidly becoming clear we need to rethink how we answer those questions.

When telescopes peer across distances of billions of light years, they are looking back in time towards the big bang. The first hints of our universe's origins in a hot, dense pinprick of infinitesimal size came in the late 1920s, when the astronomer Edwin Hubble and others noted an effect known as redshift: far-flung galaxies have redder tints than those closer by. Hubble realised that Einstein's general theory of relativity provides a remarkable explanation, that the space between galaxies is expanding, stretching passing light to longer, redder wavelengths. The degree of redshift depends on the amount of expanding space the light traverses – and thus on the distance of the light source. Since Hubble, accurate colour vision has proved to be the best way to estimate cosmic distance.

Studies in the 1990s of distant supernovae provided another unexpected twist, however. The furthest supernovae surveyed were consistently fainter than you would expect for bodies with their measured redshift – suggesting they were further away than predicted by Einstein's description of the cosmic expansion. It was as if some mysterious agent had popped up in the last few billion years and accelerated the expansion. Today, we're still no clearer what this "dark energy" is or how it works – but we now know it makes up more than two-thirds of the total mass and energy in the cosmos.

Since looking back to different distances provides us with snapshots of the universe at different times, a detailed 3D map of cosmic structures would allow us to begin to see how these forces have driven its evolution. Since 2013, the Dark Energy Survey (DES) has been using a 570-megapixel camera attached to a telescope high in the Chilean Andes to map, over five years, 300 million galaxies covering an eighth of the sky. Euclid, a European Space Agency project due to blast off in 2020, is a space telescope that will pinpoint a billion galaxies over an area of sky three times that size. The Large Synoptic Survey Telescope, again on a Chilean mountain, will top them all for sheer output of data: once complete in 2022, it will begin surveying an expected 10 billion galaxies.

Redshift tells the story of an expanding, accelerating universe (see graphic, page 44)



These projects entail an awful lot of distance measurements. "The two dimensions you have from measuring position on the sky aren't enough," says Dragan Huterer, a cosmologist at the University of Michigan, Ann Arbor. "All these surveys hinge on having depth information to see how the universe has developed over its life."

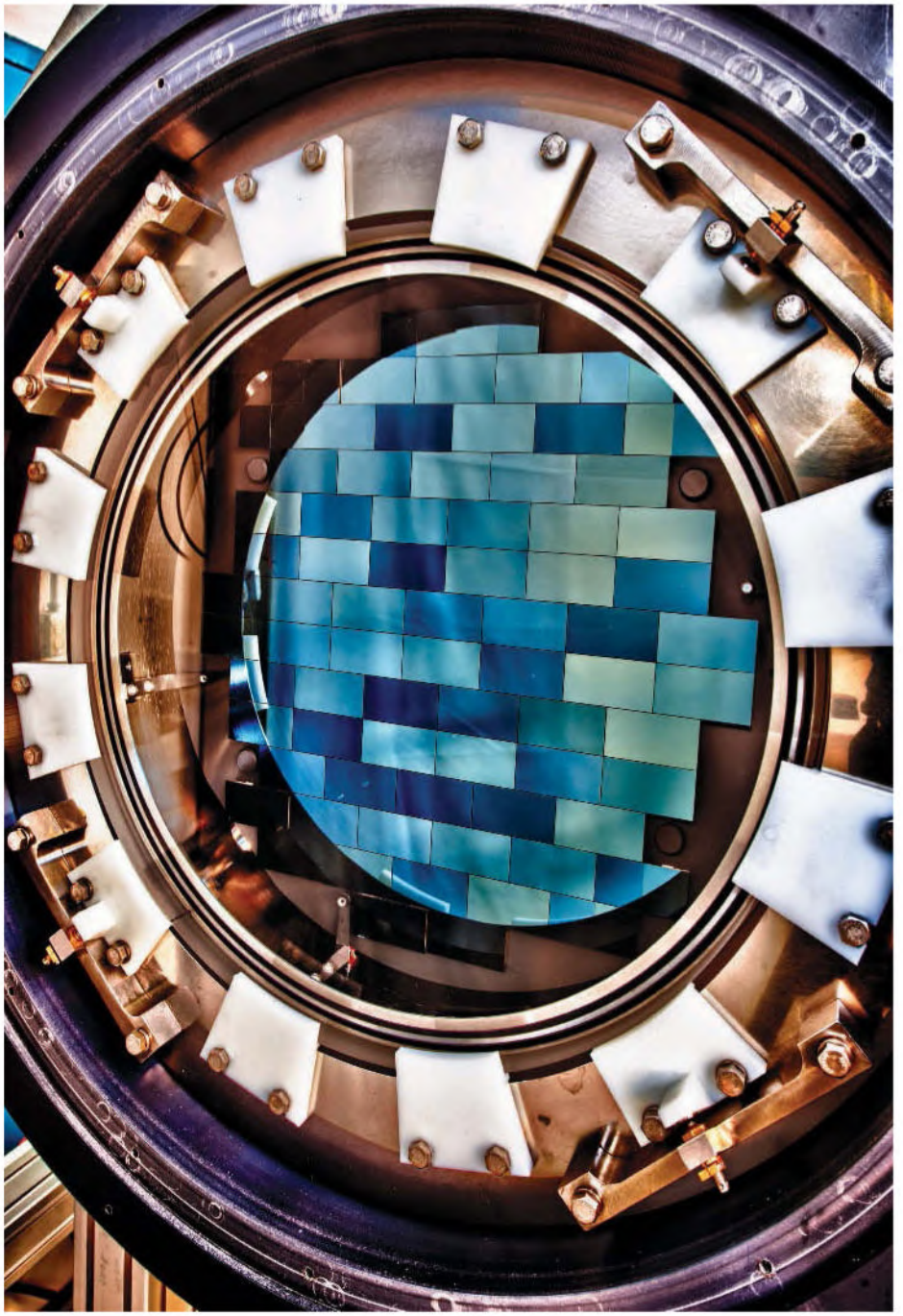
Lost in space

And that's where the small/big cow problem is really kicking in. As well as coming in a range of sizes and shapes, galaxies vary enormously in intrinsic colour. "This is when science turns into art. You need some way of working out how much the colour has changed, even when you don't know what the original looked like," says Huterer.

One way is to look at the full spectrum of a galaxy's light. Atoms and molecules in a galaxy emit and absorb specific wavelengths of light, forming a distinctive "barcode" of light and dark lines. Work out how far this pattern has moved along the spectrum, compared with a nearby, stationary light source, and that should tell you the redshift.

But this sort of forensic reconstruction is beyond the new large-scale surveys. The DES, for example, takes five snaps of every field of view, each time through a different colour filter. These exposures measure light levels averaged across a portion of the spectrum, but not the position of spectral lines. "We work with a tiny fraction of the information you ideally want," says Stephanie Jouvel of University College London, who is part of the DES team. "We can tell a lot, but we only end up with a probable answer rather than the certainty you get from a spectrum."

Getting even that requires a lot of highly educated guesswork, using tried-and-trusted galaxies for calibration, or simulations that model the expected light levels under each filter for galaxies at different redshifts, and



REIDAR HAHN/FERMILAB

The Dark Energy Survey's 570-megapixel camera aims to map the cosmos

then trying to find a match. But this tends to yield several possible matches, creating uncertainties that smudge the final map.

If that were the end of it, we wouldn't be too worried. "It's fine to be uncertain," says Huterer. "So long as you are certain about your uncertainty, you're good to go." But the universe isn't regular enough to give us that confidence: a strange galaxy emitting an unexpected colour combination can end up in entirely the wrong place. That's enough to skew our view of the universe, rather as an outsider's view of Earth would be skewed if a data blip showed just a few cows roaming the wastes of the Antarctic. "If you put even a few galaxies in a catastrophically wrong place, you get the wrong answer about the universe. It's as simple as that," says Huterer.

One solution the DES team is investigating involves neural networks: chunks of code that process data in a way loosely inspired by the interlinked cells of the human brain. The network's sensory inputs are the five raw numbers representing the filtered colour intensities, and its output is a single number for the redshift. Just as a baby's brain learns with repeated exposure to react appropriately to familiar stimuli, and then progresses to unfamiliar ones, the network's algorithm is trained by showing it pictures of galaxies with surer redshifts, and allowing it to run until it makes sense of things. "The computer learns to get an answer for itself," says Jouvel.

Faced with the complexity of the real universe, these self-taught systems often pick up on subtle hints that the models miss. So far they're also five to 10 times as fast – a significant improvement when dealing with hundreds of millions of galaxies.

Yet the neural network still fails catastrophically on some objects emitting strange colours, and does even worse with things that aren't conventional galaxies. Quasars are extremely luminous sources of light thought to be powered by supermassive black holes. They shine so brightly that they can be seen tens of billions of light years away, so are essential for filling out our map to the farthest possible distances. They also have few identifiable colour traits, meaning their chance of being put in completely the wrong place is even greater than normal.

Not all is lost. Cosmic objects aren't scattered at random, but tend to lie along a relatively well-defined web of structures. Galaxies and quasars with accurate redshifts can be placed with confidence in this web, providing a clue as to where others must slot in."We think of it like a puzzle; we can slide the troublesome objects around until the whole thing locks together," says Matt McQuinn at the University of Washington in Seattle. He and his colleagues have been developing heavy-duty statistical methods to make that happen. "The fundamental goal is to get probabilities that each redshift assignment is correct, so that we at least know how wrong things are going," he says. Several studies show that this improves on the accuracy of the output from neural networks significantly.

Although enthusiastic about these innovations, Huterer is clear that more are needed. "It's part of the solution, but on its own it's still insufficient," he says. Getting to grips with dark energy and the story of cosmic evolution means measuring billions of distances to an accuracy of 0.1 per cent, he says, and that will require a whole battery of tricks from statistics and astrophysics. We cosmologists may be needing a little more time to sort out our cows. ■

Andrew Pontzen is a cosmologist at University College London

For more on redshift, see graphic on next page ›

THE LOWDOWN ON REDSHIFT

HOW can we make an accurate map of the universe when telescopes deliver only a two-dimensional picture? Measuring how far away cosmic objects are is no trivial affair – we can't move our surveying equipment or lay a tape measure between galaxies.

For the best part of a century, the answer has been to measure redshift. In the 1920s, astronomer Edwin Hubble and others discovered that light from galaxies beyond the Milky Way is consistently shifted to longer, redder wavelengths.

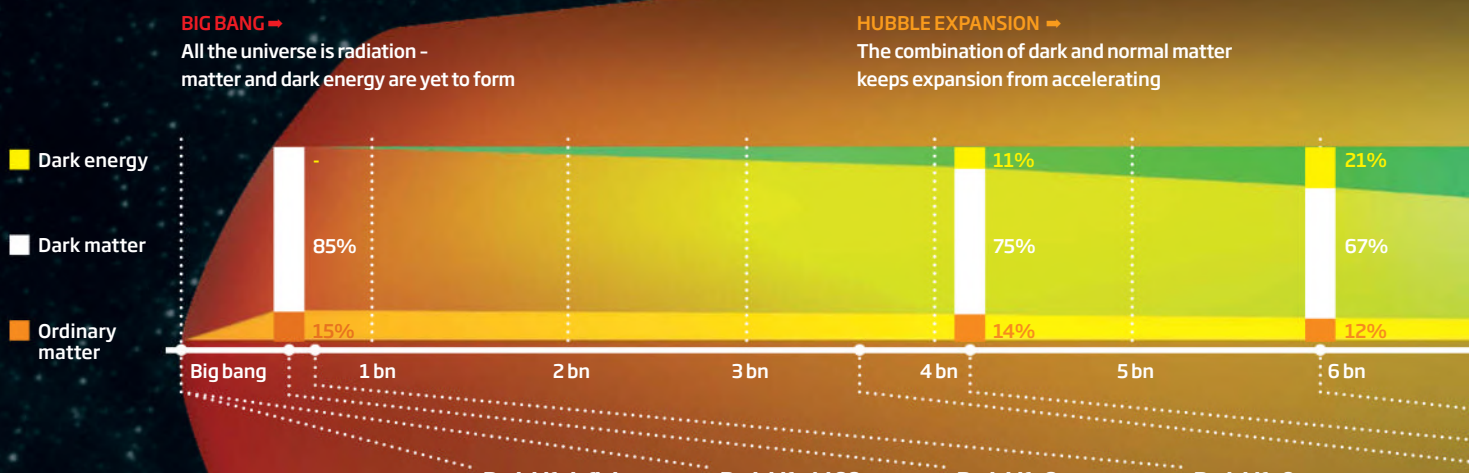
This was the first inkling that the universe began in a big bang, and has been expanding ever since. The reason for the shift in colour is that as space-time expands, it stretches the light passing through it.

The more expanding space the light has passed through, the greater the degree of this redshift, so far-off objects appear redder. We also see these objects as they were earlier in the universe's history because of the length of time the light has been travelling.

Redshift measurements have brought surprising discoveries, not least that the universe's expansion has apparently begun to accelerate, something attributed to an enigmatic "dark energy". Cosmic maps extending to even more distant objects and covering more of the sky should help us work out what is going on – provided our redshift measurements are accurate (see page 42).

The cosmic story

Redshift measurements reveal how the tussle between matter and dark energy has determined the universe's evolution



Redshift values are related to the movement of the spectral lines (see "Splitting the difference", above right) and the expansion of the universe. Accurate redshifts are important to establish what sort of structures existed at what eras in the universe, and thus how factors such as dark energy and invisible dark matter have influenced cosmic evolution. The aim of a new generation of instruments is to refine our measurements and build a more accurate history of the universe. Among these instruments are the Euclid space probe and the Dark Energy Survey and Large Synoptic Survey telescopes.

Redshift infinity

BIG BANG

The equations of general relativity, which describe the universe's evolution, break down in the earliest moments of its history. No light from this time is visible to us

Redshift 1100

380,000 YEARS

The earliest light we can detect comes from this era. Its redshift is so extreme that the light now exists only as microwaves. This is the cosmic microwave background

Redshift 9

570 MILLION YEARS

The current furthest known galaxy, EGSY8p7, had formed by this time. It was found lurking in an image from the Hubble Space Telescope and confirmed by detailed observations using the Keck telescope in Hawaii in August 2015

Redshift 8

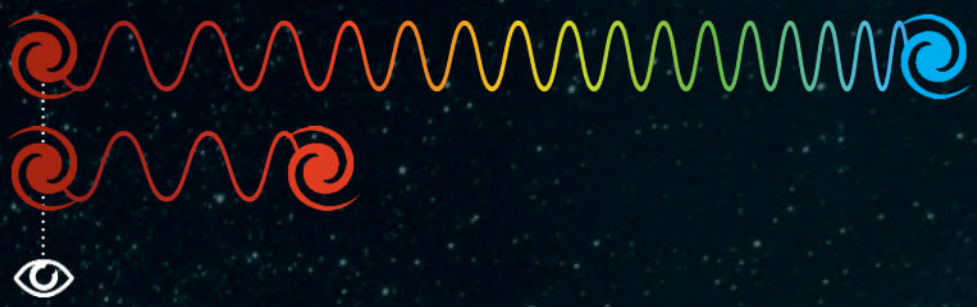
700 MILLION YEARS

Redshift 8 forms a barrier to observations using most wavelengths of light. NASA's future James Webb space telescope and the European Southern Observatory's new ALMA facility will try to stare beyond this frontier by looking for infrared radiation and radio waves

Shift key

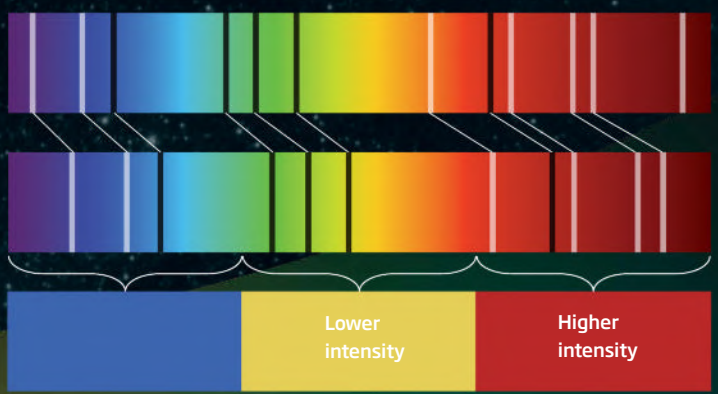
The more an object's light has shifted to longer, redder wavelengths, the greater the distance through expanding space the light has travelled, and the further back in time we see the object.

Or that apparently far-off entity might be a naturally reddish object, closer in. This is the central conundrum of redshift.



Splitting the difference

Atoms and molecules emit and absorb light at specific wavelengths, creating a barcode-like pattern of bright and dark lines in a galaxy's spectrum. A full spectrum lets you assess how each line has shifted, and obtain a consistent value for the redshift. However, large-scale galaxy surveys typically average light intensities over bands of the spectrum. Higher intensities imply lots of bright spectral lines within a band, lower intensities imply more dark lines. This may or may not be enough to work out where the spectral pattern is, and hence the redshift.

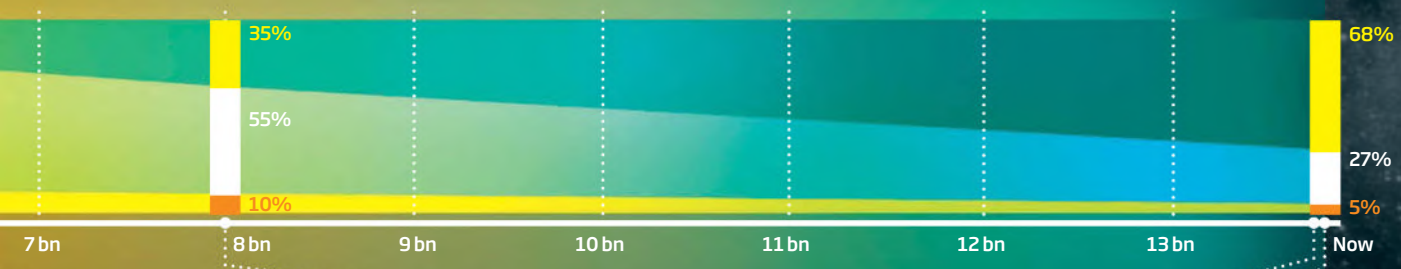


Actual spectrum
A galactic spectrum has light and dark lines at specific wavelengths

Redshifted spectrum
The original wavelengths are multiplied by a consistent factor

Averaged spectrum
Without lines, only bands of increased or decreased intensity can be seen

DARK ENERGY DOMINATES ➡
In recent cosmic times, dark energy has begun to counter gravity, accelerating the universe's expansion



Redshift 1.9
3.6 BILLION YEARS
The furthest supernova so far found lies at this redshift. Supernovae help us grasp cosmic evolution, but they are short-lived and therefore hard to find. The Large Synoptic Survey Telescope in Chile will search for specimens up to 10 billlion light years from us

Redshift 1.6
4.2 BILLION YEARS
The universe was smaller in the past. As a result, beyond redshift 1.6, the light rays reaching us bend in a way that causes objects to look bigger, contrary to our everyday experience of distant objects appearing smaller. This complex relationship between size and redshift can be used to characterise dark energy

Redshift 1
6 BILLION YEARS
Galaxies become hard to detect at redshifts above 1 because their distance makes them appear so faint. An alternative is to make use of quasars: rare but extremely bright pinpricks of light emitted by gas getting squeezed into black holes

Redshift 0.6
8 BILLION YEARS
The complex web-like distribution of galaxies revealed by the Sloan Digital Sky Survey has been used to explore the universe's expansion at redshifts up to 0.6, corresponding to the past five or so billion years

Redshift 0.003
13.76 BILLION YEARS
Edwin Hubble's observations in the 1920s established the crucial relationship between redshift and distance. They covered just a tiny fraction of what we can study today

Redshift zero
13.8 BILLION YEARS
Objects in our immediate neighbourhood – the solar system, nearby stars, and galaxies such as Andromeda – appear in their true colours, without redshift. They are the exception rather than the rule

Capturing the universe

A surprise bestseller in Italy provides a sensationally good physics primer, finds **Daniel Cossins**

Seven Brief Lessons on Physics by Carlo Rovelli, Allen Lane, £9.99

NASA, ESA, J. TRAUGER (JET PROPULSION LABORATORY)

CARLO ROVELLI remembers the first time he glimpsed the beauty of Einstein's theory of general relativity. He was an undergraduate lounging on a beach in southern Italy, leafing through a rodent-nibbled textbook. "Every so often I would raise my eyes from the book and look at the glittering sea: it seemed to me that I was actually seeing the curvature of space and time."

For Rovelli, now a distinguished physicist at the University of Aix-Marseille in France, the simple equation encapsulating Einstein's big idea conjures breathtaking visions of exploding universes, the gravity of planets slowing time, and space collapsing into endless holes or rippling like the surface of the sea.

This may sound like the ravings of a lunatic, says Rovelli, but it is reality – or at least "a glimpse of reality, a little less veiled than our blurred and banal everyday view of it". It's hardly surprising, then, that he describes relativity as an "absolute masterpiece", with the same power to move as Mozart's *Requiem* or the Sistine Chapel.

His brilliant *Seven Brief Lessons on Physics* does a remarkable job of vindicating that claim, and much more besides. In a mere 78 pages, he paints a magnificent fresco, depicting with sweeping brushstrokes the great ideas and discoveries that revolutionised physics and our understanding of the world in the 20th century. He also sketches out the remaining riddles and physicists' attempts to solve them.

The result is exhilarating. Rovelli writes with clarity and verve, vividly bringing to life concepts that can often appear incomprehensible, and inviting readers to see the world anew.

Aimed squarely at "those who know little or nothing of modern science", his lessons are nothing like the stodgy stuff of schooldays. You breeze through general relativity and quantum mechanics. Time dilation, black holes, particles existing in multiple places at once – all are covered in the first 20 pages, leavened with well-chosen analogies and brief appearances from the main characters in this epic story of discovery.

"Rovelli calls relativity an 'absolute masterpiece', with the same power to move as Mozart's *Requiem*"

Then, with a few simple diagrams, he helps us comprehend the architecture of the universe and get to grips with elementary particles, before rattling through the failures of the standard model and the mystery of dark matter.

It's not just for novices, though. There is just about enough of the here and now to reward the well-versed reader. Take Rovelli's chapter on the thermodynamics of black holes and what this tells us about the flow of time, or another devoted to a theory he and others are still thrashing out as part of the ongoing struggle to reconcile gravity and quantum mechanics.

Loop quantum gravity, for the non-cognoscenti, is the idea that space is neither continuous nor infinitely divisible. Instead it is made of grains, each a billion billion times smaller than the smallest atomic nuclei. They are called loops, he says, "because they are linked to each other, forming a network of relations which weaves the texture of space, like the rings of a finely woven immense chain mail".

A breathtaking glimpse of modern physics and cosmology

For his final trick, Rovelli muses on our place in the universe, the human mind and how we build our conceptions of the nature of reality. It's a fitting way to end, even if the conclusion rambles on more than you have come to expect.

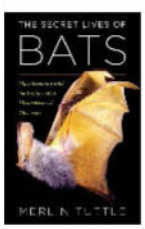
The book was a sensation in Italy, where it topped the sales charts for two months earlier this year. It's not hard to see why: few writers, let alone physicists, capture the beauty of nature and the excitement of its discovery in such clear, rich prose.

Of course, the book is far from comprehensive. Long-winded explanations are sacrificed in favour of lean, lucid descriptions. But it's hard to imagine a more coherent, inspiring introduction to modern physics. It really is an enchanting little volume. ■

The real batman

Transforming the bat's image takes true grit, says **Stephanie Pain**

The Secret Lives of Bats: My adventures with the world's most misunderstood mammals by Merlin Tuttle, Houghton Mifflin Harcourt, $26



THE biggest secret in Merlin Tuttle's thrill-filled account of his bat-obsessed life is how he survived to tell his amazing tales. Tuttle is a legend in bat circles and this very personal and highly entertaining account of his experiences over the past five decades reveals why.

In *The Secret Lives of Bats*, Tuttle recounts his globe-trotting adventures in pursuit of these maligned animals. Nothing, it seems, can deter him – not even shotgun-toting moonshiners in Tennessee, spear-waving bandits in Kenya or rival bat-hunters in Thailand, who make their living poaching bats for the restaurant trade. He has narrowly escaped all manner of unpleasant deaths such as drowning and being trampled by a charging elephant, and suffered the destruction of a sizeable chunk of his lungs by ammonia rising from piles of bat dung.

But Tuttle is a legend for another reason too. He has probably done more than anyone else to change people's attitudes towards bats, turning fear and loathing into fascination and respect.

Early on in his career, Tuttle became a man on a mission. As an ecologist, he wanted to find out more about the biology and behaviour of bats. As a conservationist – he founded Bat Conservation International in 1982 – he never passed up an opportunity to change the minds of people who think the only good bat is a dead bat.

As he explains, extolling the virtues of bats as vital pollinators and seed dispersers certainly helps. But show a potato grower bat droppings packed with the remains of their worst enemy, the Colorado potato beetle, and they are instantly persuaded. Point out how much money Texan farmers would save if they let bats control the pests that cost them most, and a whole state learns to love moth-devouring bats.

Tuttle never hectors. No matter how hardened a bat-hater he meets, he lays out the facts and lets them speak for themselves, sometimes even producing a small, cute bat as a convincer. But, as he points out, you can't always have a bat with you. You can, however, change perceptions with a stunning photograph.

"You can't always have a bat with you, but you can change perceptions with a stunning photograph"

MERLIN D. TUTTLE

Merlin Tuttle risks life and limb to portray bats in a better light

Fed up with the usual scary images that accompanied most bat-related articles, Tuttle tried to find photographers to picture them in ways people would warm to – nurturing their young, pollinating flowers – and get action shots of them doing things never seen before. The problem was no one else was willing to subject themselves to the horrendous conditions in bat caves. So Tuttle took the task on himself. Some of his images have become world famous.

Best of all, though, are the book's revelations about the bats themselves. Vampire bats have a social structure akin to that of primates, sharing food and information, adopting orphaned young and practising reciprocal altruism – something humans, chimps and wild dogs do. Frog-eating bats pinpoint their prey by their calls, and have evolved unique hearing that allows them to detect both the high-pitched squeaks of their echolocation system and the low-frequency sound of calling frogs.

Sadly, as Tuttle reminds us, bats are still demonised in some quarters. Last year, the government of New South Wales sanctioned the destruction of colonies of flying foxes. Why? In 1996, Hendra virus was discovered in Australia. It killed four horses a year on average and two people died after contracting the disease from horses. Fruit bats are the main host so they got the blame. But tests have shown the only animal capable of transmitting the virus to horses is the domestic cat. Tuttle's work is not done yet. ■

Stephanie Pain is a consultant for *New Scientist*

email recruitment.services@rbi.co.uk
UK tel +44 (0)20 8652 4444
UK fax +44 (0)20 8261 8434
US tel +1 617 386 2190
US fax +1 617 397 2805
US email nssales@elsevier.com

Phico Therapeutics Ltd, Babraham Research Campus, Babraham, Cambridge CB22 3AT

Molecular Microbiology Scientists

37.5 hours per week; 25 days holiday;
Salary commensurate with experience and qualifications (range £18-35k)

We are currently recruiting Molecular Microbiology Scientists to work in our Molecular Biology department in Cambridge, UK. Phico Therapeutics is a biotechnology company developing novel drugs for the treatment of bacterial infections, to address the serious issue of increased antibiotic resistance worldwide. Phico's revolutionary SASPject technology uses tailored delivery vehicles to deliver the gene for antibacterial protein, SASP. Initial targets are Pseudomonas aeruginosa and E. coli/Klebsiella pneumonia. We are seeking both post-doctoral and graduate level scientists with a background in molecular microbiology to join a team of 20 scientists. Candidates must be enthusiastic, inventive and flexible. An interest in bacteriology and bacterial genetics is essential, and PhD-level candidates must have practical experience in the genetic modification of bacteria. BSc/MSc qualified candidates must have molecular biology experience. Phico provides a friendly working atmosphere where team work is essential. If working hard towards the goal of developing potentially life-saving products appeals to you then **please send a 2-page CV and a covering message to Adam Wilkinson aw@phicotx.co.uk. If required, publication lists can be appended to the CV.**

Closing date: **Friday 13th November 2015.**

PHICO THERAPEUTICS

IONTAS

IONTAS is a biotechnology company focussed on the development of novel antibody therapeutics in the areas of cancer and inflammation. We use phage display and innovative technology to accelerate all aspects of antibody drug discovery from target selection through to the generation of human antibody drug candidates. Since commencing operations in 2012, IONTAS has partnered with 9 USA and European biopharmaceutical and biotechnology companies on multiple antibody discovery projects. IONTAS cultivates a dynamic, innovative environment resulting in several recent patent filings.

Research Scientist - Immunology

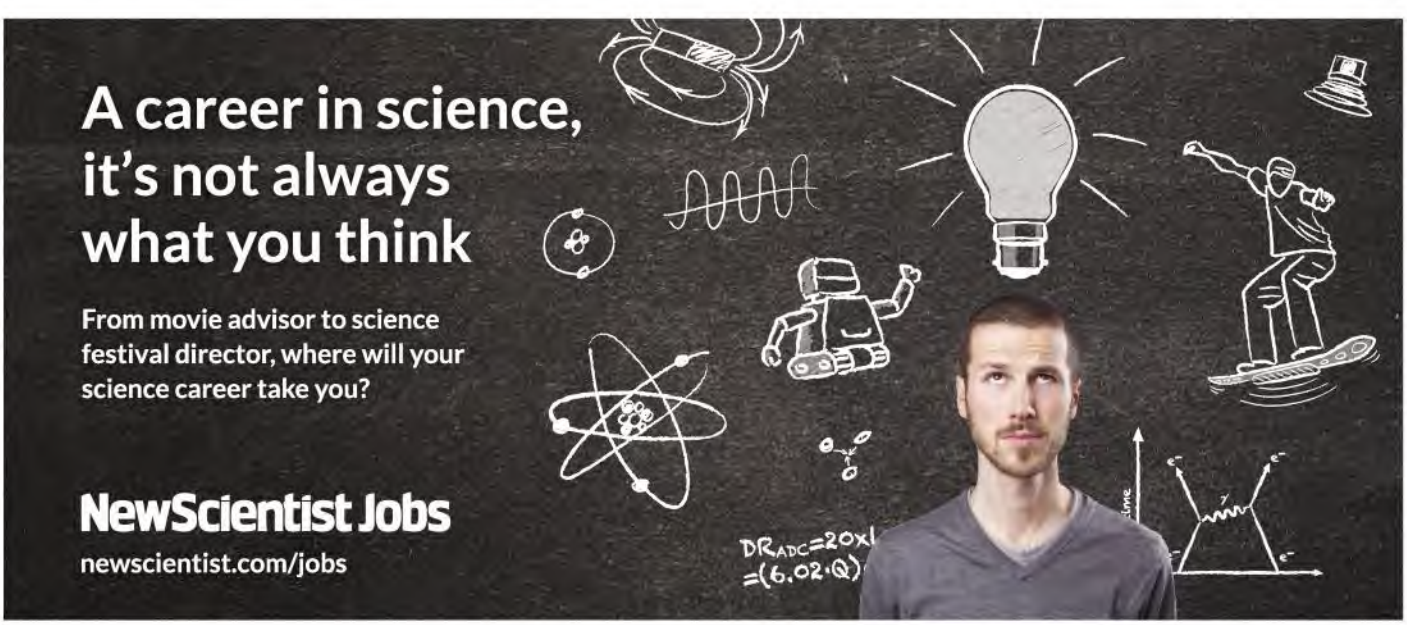
We are looking for an experienced immunologist to play a central role in the design, development & execution of cell-based assays to aid in the selection of antibodies for pre-clinical development in areas such as immuno-oncology, cancer and inflammation. As an integral member of the scientific team, the candidate will be expected to actively contribute to the further development of the IONTAS mammalian display technology platform to accelerate antibody, T cell receptor (TCR) and chimeric antigen receptor (CAR) therapeutics. Applicants will possess a PhD in immunology, or equivalent experience, with practical knowledge of cell biology assays and flow cytometry. Experience of cytokine release, co-culture and reporter assays and the maintenance of primary cells (e.g. T cells) would be an advantage.

Research Assistant - Molecular Biology

An opportunity has arisen for a research assistant to join the company to play a key role in antibody lead isolation and optimisation. This role will involve antibody phage display selection, high-throughput cloning, antibody screening by ELISA or HTRF, sequence analysis, expression of antibodies in E. coli and mammalian cells and affinity purification. Applicants will possess a BSc with relevant laboratory experience in molecular biology techniques. Experience of the following areas/techniques would be an advantage: phage display and antibody engineering, plate based ELISA and HTRF assays, protein expression in E. coli and mammalian cells and protein purification using batch or chromatography methods

Excellent communication skills (written and oral) and ability to thrive in a dynamic team environment are pre-requisites for both roles.

Salaries are competitive and include the opportunity to participate in the company share option scheme. To apply for these positions, send your CV and covering letter outlining your suitability for this role with two reference contact details to **jobs@iontas.co.uk**



The hottest jobs for graduates

National Graduate Recruitment Exhibitions

6 & 7 November | NEC, Birmingham

More than just a jobs fair...

- Mock Assessment Centre
- CV Clinic
- Careers Advice Clinic
- Presentations & workshops
- GradJobs High Flyers' Club*
- Subsidised travel*

Get your ticket at GradJobs.co.uk

1000s of jobs with companies including:

nielsen, sky, LIDL, enterprise rent-a-car Come alive, adidas GROUP, BAE SYSTEMS INSPIRED WORK, NFU Mutual, WE GOT CODERS, T.K.maxx, ALDI, News UK, deVere GROUP GLOBAL WEALTH ADVISORY, Ofcom, HILTI, BOSCH Invented for life, HSS Hire You're better equipped, Travis Perkins, CBRE, sogood

Headline sponsor: theguardian careers

Sponsor: GradJobs

Birmingham event in association with: UNIVERSITY OF BIRMINGHAM, Aston University Birmingham

*Please check the website to see which recruiters are at which exhibition. Terms & conditions apply. All information correct at time of press.

letters@newscientist.com @newscientist newscientist

EDITOR'S PICK

More than one way to slice odds

From Roger Carpenter

David Deutsch rightly points out that the conventional view of probability – that it is the frequency with which a phenomenon is observed – is very seldom of any real use (3 October, p 30). There are many situations in which we can talk quite meaningfully about probabilities, for which there cannot possibly be a series from which a frequency can be estimated: What is the probability of life on Mars? What is the probability I will die tomorrow? Or even: What is the probability that the 100th decimal digit of pi is 6?

But because – like so many physicists – he assumes this is the only kind of probability, he comes to the conclusion that probability itself is a useless concept. In fact there are several ways of viewing probability, of which the most compelling is to regard it as a perception, computed by the brain, rather as colour is computed from wavelength.

Much recent work, recording from neurons in the cerebral cortex, has demonstrated that probability is the language in which neurons talk to each other. At a deeper level, the whole point of the brain is to estimate the probabilities of events in the outside world, including the consequences of our actions, so we are more likely to survive. Probability is subjective.

Cambridge, UK

Is it qualia all the way down?

From Ed Subitzky

Michael Slezak poses the tantalising question, "If time does not flow, what makes us think it does?" (5 September, p 30). The answer to this question may not lie in physics, but in neuroscience or even in philosophy.

For aeons, both scientists and philosophers have tried to get to grips with what they call the "qualia" of our daily experience – the direct and seemingly irreducible "redness" of red, the "blueness" of blue. It is hard to believe that such things exist objectively in our universe, so they appear to be "subjective" creations of the brain.

Are time and space simply the canvas upon which qualia play out, or are they themselves qualia, just like red and blue? If so, time and space are subjective. If time is real, then it is perhaps not so surprising that the brain, existing within time, gives us the impression of time. If time is unreal, the mystery of the illusion is a deep one, indeed.

New York, US

The roots of consciousness

From Guy Cox

Paul Mealing writes "For plants, conscious feelings would have no benefit. What's the point of experiencing fear or pain if one can't avoid its source?" (Letters, 19 September). But that is an animal-based view. Plants respond rapidly and vigorously to attacks, whether wounds or infection. And some plants move fast – think of the Venus flytrap.

Even in the unicellular world, organisms avoid unpleasant stimuli and seek out useful ones. At what point one starts to call avoiding unpleasant stimuli "pain" is purely semantic. Fear is more relevant, since it implies memory. Plants have a "memory" of a sort – they will mount a more rapid attack to a second infection, for example. Molluscs certainly have it. From experience, you can go up to an open giant clam and clip off a little bit of its mantle. It will snap shut, of course, but after that if a human approaches it will snap shut before you get close – it has learned to fear you.

Sydney, New South Wales, Australia

From John Hastings

In all *New Scientist* articles on consciousness I have read, I cannot recall any mention of its role in learning and teaching. As a lecturer, I had to put conscious thought into preparation of my teaching plans and I had to be conscious in order to deliver a lecture. Equally, the students had to pay conscious attention, notwithstanding the joke that defines a lecture as "a process of transferring information from the notes of the lecturer to the notes of the student without it passing through the brains of either".

Those who downplay consciousness or regard it as a by-product need to demonstrate how teaching and learning could take place without it.

Whittlesey, Cambridgeshire, UK

Hive mentality or blockchain bloat?

From Eric Davidson

Thank you for an excellent article on how the blockchain mechanism could be used in a variety of applications (12 September, p 18). But the blockchain records will expand as transactions are added, especially when they are replicated on all the systems they are used on. How will they be archived?

Dollar, Clackmannanshire, UK

From Donald Windsor

Blockchains seem to mimic with proof of ownership what social insects do with proof of membership. After all these millennia of suffering from top-down despotism, we humans seem finally to be able to attain a hive mentality.

Norwich, New York, US

The runaway train problem, again

From Alec Cawley

Why is anyone surprised by the response to the runaway train problem (26 September, p 36)? The first solution, of throwing a human off the bridge, requires reframing a human as a useful mass. It is this reframing, not the throwing of the mass in the path of the train, which is abhorrent.

I certainly could not achieve it in the available time, and would find it extremely painful given time for leisurely consideration The alternative, of throwing a switch to save five lives at the cost of one, is simple arithmetic which we can do at emergency speed.

Implicit in every morality is the concept that the world is divided into two domains – people and stuff. People deserve respect, stuff does not. Atrocities occur when people are treated as stuff.

Penwood, Hampshire, UK

From Martin Greenwood

Unrealistic questions are likely to produce unrealistic answers. Unless one is an employee of the railway company, it is implausible that one could ever know enough to decide that changing a set of points (a switch in US parlance) might save lives. And it is even more implausible that tossing a person, no matter how obese, onto the tracks will slow a train sufficiently to alter the damage it will do. Besides, the questions seem to assume one is operating in a legal vacuum.

If I do nothing, the worst I can be accused of is cowardice. If I intervene in any way, no matter how well intentioned, I may well

"So much for David Cameron's pledge to make his the greenest government yet"

Rebekah Mayne responds on Facebook to our report that the UK government could face a lawsuit over climate failures (10 October, p 6)

find myself charged with murder. If you believe a person on the tracks will stop the train, why not jump off the bridge yourself? Or shout at the five people: jump!
Stirling, Western Australia

Liberate mavericks to be creative

From Bruce Denness
Donald Braben recognises that a key obstacle to creative research is the use of peer review as the gold standard for deciding what gets funded (12 September, p 24). Peer review does achieve mediocrity more efficiently.

Most of us could identify one or more scientific mavericks, not all of them academics. I suggest they should be invited to nominate contenders for an award. A panel could then select the recipients. That would circumvent the stultifying grip of peers.
Whitwell, Isle of Wight, UK

From Terence Hollingworth
Braben asserts that we must either find an alternative to capitalism or "ensure we have an adequate flow of technological change" to meet capitalism's demand for incessant growth. The former is the only option. Continual growth is an impossibility. Let's have progress, scientific and intellectual, that would mean valuing equilibrium, not growth, and working towards sustainable development.
Blagnac, France

Dark matter that goes 'bonggg'?

From Andy Howe
Thank you for the fascinating postulate that dark matter might be clumps of quarks, "as dense as neutron stars", and that a teaspoon of them would weigh "as much as a mountain" (22 August, p 28). What happens, however, if one of these macro-particles happens to pass through the NAUTILUS gravitational wave detector's couple of tonnes of supercooled aluminium like an ultra-dense, hypersonic bullet? I can't help thinking that the cylinder would do rather more than "deform ever so slightly".
Sheffield, UK

The editor writes:
■ The researchers tell us that macros massive enough to have such an effect are predicted to be so rare that we'd have to wait billions of years to "see" one; those arriving more frequently would have much smaller masses.

My own personal earworm triggers

From Paul Dormer
Ed Hannah reports looking for things that can trigger earworms (Letters, 12 September). This reminds me of having *The Ballad of Robin Hood* in my head on moving to a new office. I'd not heard it for about 20 years. My office was close to a stairwell. Whenever someone used it, the closing door beat out the rhythm of the song's opening fanfare.

Recently I have noticed at London's Waterloo station that the sounds played to tell us the train doors are unlocked make me hum the opening of Prokofiev's first piano concerto.
Guildford, Surrey, UK

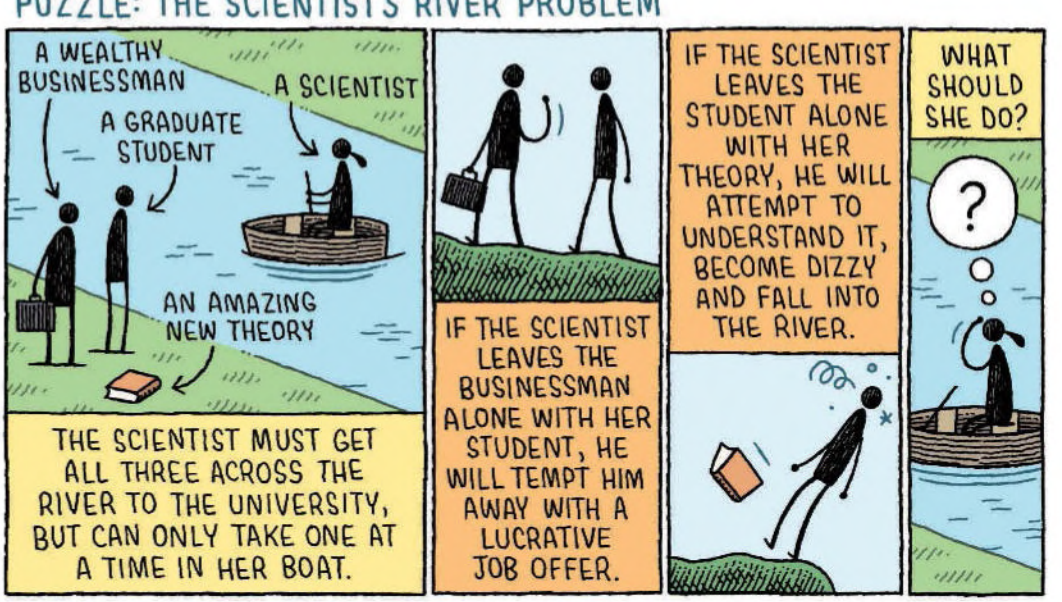
This is where the universe began

From Graham King
Like many, I thoroughly enjoy reading your articles on big scientific questions, particularly in cosmology (5 September, p 30). One thing we can categorically state about the big bang is we know where it happened: here.
Matcham, New South Wales, Australia

No metal, no cry

From Richard West
Your report that most nearby planets in habitable zones probably have less iron and other metals than Earth (19 September, p 17) may explain the absence of other technological civilisations in our galaxy. With few metals it would surely be difficult for any intelligent life to proceed beyond a stone age. Perhaps we are the first to develop radio.
Bristol, UK

TOM GAULD



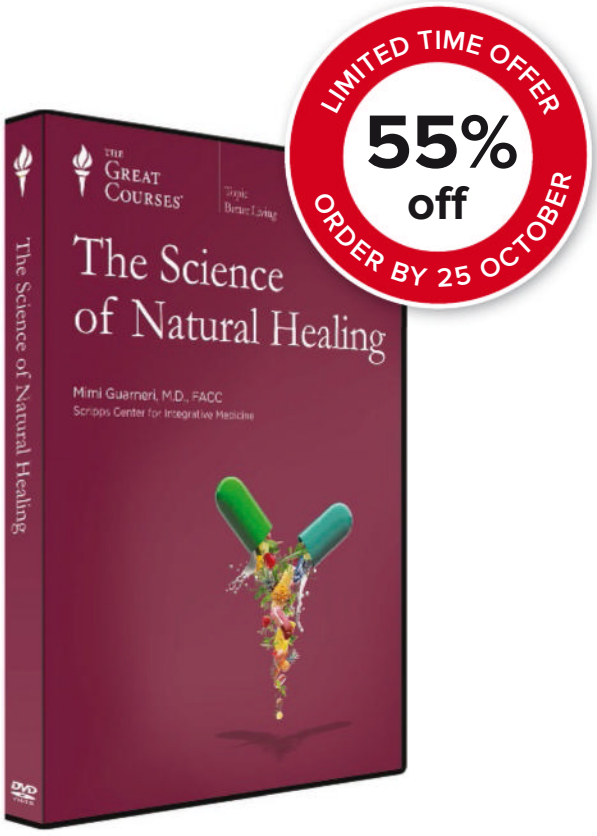
For the record

■ **Our review of *A Prehistory of the Cloud* degraded slightly: JPEG image files commonly degrade when saved (5 September, p 45).**

■ **A current of 1 amp is in fact 6.24150934×10^{18} electrons per second (3 October, p 38).**

Letters should be sent to:
Letters to the Editor, New Scientist, 110 High Holborn, London WC1V 6EU
Email: letters@newscientist.com

THE GREAT COURSES®



Discover Nature's Power to Heal

Have you ever wondered if there are scientifically valid alternatives to the drugs so commonly prescribed in our health care system? Get answers you can trust from board-certified cardiologist Mimi Guarneri, founder of the Scripps Center for Integrative Medicine, in **The Science of Natural Healing**. These 24 compelling lectures from an award-winning doctor are an eye-opening exploration of holistic health care and the many effective natural treatments and methods—food included—that are both clinically proven and readily available.

You'll look deeply into the science behind these natural treatments and preventive health care, including how medical conditions ranging from high blood pressure to heart disease and diabetes can be treated naturally with remarkable effectiveness.

Offer expires 25/10/15

THEGREATCOURSES.CO.UK/9NSC

0800 298 9796

The Science of Natural Healing

Taught by Professor Mimi Guarneri, M.D.
SCRIPPS CENTER FOR INTEGRATIVE MEDICINE

LECTURE TITLES

1. Shifting the Health-Care Paradigm
2. Understanding Holistic Integrative Medicine
3. You Are More Than Your Genes
4. Food Matters
5. Not All Foods Are Created Equal
6. Natural Approaches to Inflammation
7. Food Sensitivity and the Elimination Diet
8. Vitamins and Supplements
9. Herbal Remedies
10. Lowering Cholesterol Naturally
11. Treating High Blood Pressure Naturally
12. Treating Diabetes Naturally
13. Stress and the Mind-Body Connection
14. Turning Stress into Strength
15. Meditation, Yoga, and Guided Imagery
16. Natural Approaches to Mental Health
17. Biofield Therapies
18. The Power of Love
19. Spirituality in Health
20. Components of Spiritual Wellness
21. Applying the Lessons of Natural Healing
22. Ecology and Health
23. Healthy People, Healthy Planet
24. You Are Your Own Best Medicine

The Science of Natural Healing
Course no. 1986 | 24 lectures (30 minutes/lecture)

SAVE UP TO £30

DVD ~~£54.99~~ NOW £24.99
CD ~~£35.99~~ NOW £24.99
+£2.99 Postage and Packing
Priority Code: 110682

For 25 years, The Great Courses has brought the world's foremost educators to millions who want to go deeper into the subjects that matter most. No exams. No homework. Just a world of knowledge available anytime, anywhere. Download or stream to your laptop or PC, or use our free mobile apps for iPad, iPhone, or Android. Over 550 courses available at www.TheGreatCourses.co.uk.

PAUL MCDEVITT

A PALEO diet may be fashionable these days, but is it compatible with religious sensibilities? Roy E. Plotnick and his colleagues ponder this important question at length in a paper entitled "Jurassic Pork: What Could a Jewish Time Traveler Eat?", prompted by a student's query over whether brachiopods – abundant in fossil records – were kosher.

In their paper, the authors compare the morphology of extinct fauna with definitions of "clean" and "unclean" animals in Jewish texts, to deduce what, if anything, an observant chrononaut could eat.

Unfortunately for those visiting the Cretaceous, bronto-burgers are off the menu. Dinosaurs lack the necessary cloven hooves to be considered among other large kosher herbivores, and even if viewed as distant relatives of birds, most lack the requisite "extra toe". Ocean-dwelling plesiosaurs are likewise off limits, as Leviticus forbids the consumption of "the great lizard".

However, the Jewish time traveller need not starve. "Primitive but possibly kosher duck and goose relatives are known from Antarctica at this time," the authors write. "There are fish, including bowfins, gars, sawfish, paddlefish and sturgeon." If that wasn't enough to whet your appetite for prehistoric cuisine, there were also plentiful grasshoppers and crickets to dine on (with wild honey?).

As for the student's original inquiry? Brachiopods are certainly not kosher, they are shellfish.

THE lack of women in the science industry is a perennial problem, matched only by the number of ill-judged campaigns launched to cajole them into the life scientific.

Previously, Feedback has found that dolls were both the cause and the solution to this problem (19 September). Now, EDF energy has launched its own effort to diversify the talent pool and, in their words, "change teenage girls' perceptions of science".

EDF's "inspiring role models" include a cosmetic scientist and the CEO of a fashion app, and the whole endeavour is laid out under the strapline "Pretty Curious".

Yes, once again it appears that young women can only be attracted to science through their own latent interests, which extend to make-up and fashion.

Feedback is unsure why so many campaigns to boost the number of women in science are based on the premise that it is women's attitudes that need changing. Nor is it clear why the female scientists of tomorrow are so often pigeonholed as living dolls interested only in make-up and clothes. Perhaps what is needed is a campaign to change perceptions of teenage girls.

CRITICISM of EDF was borne swiftly on the wings of social media, and if the agency behind the campaign was aware of previous misfires in this area (bit.ly/NS_girlthing), it was sticking to the script. The name "Pretty Curious", it said, "was chosen to tackle the stereotype head on and create conversation around what is a very real societal issue". EDF's social media team spent days repeating this line on Twitter, but we don't imagine this was quite the conversation they had in mind.

AMONG the peculiar joys enjoyed by those in the US medical insurance system are Byzantine billing systems and a bureaucratic insistence on patient privacy.

Encountering problems with the first, one of our US correspondents emailed the billing office. The next day he received a message saying, "You have received a secure message from Partners HealthCare or one of our hospital sites" and requesting that he download an attached HTML document.

In short, it looked uncannily like an identity-theft scam, so our correspondent emailed a copy of the message to the billing office asking if they had sent it. They replied with a similarly obfuscated message, complete with an HTML document attached. Confirmation, of a kind?

FEEDBACK has puzzled over items whose overwrought design renders them impractical (19 September). Nik Whitehead offers further evidence of this trend from his local cinema in Swansea: an ice-cream spoon shaped like a flattened trident. "This is totally unsuited for eating ice cream, unless it was a sneaky collaboration with the manufacturer of washing powder," he writes. "As it is very good for creating ice-cream stains on your shirt."

ANOTHER design problem: BuzzFeed news reports that the UK's Metropolitan police commissioner Bernard Hogan-Howe sought a fanciful approach to cutting knife crime. "I've tried to find out whether we can get dogs to search for knives," he informed an audience at London's City Hall. "They told me it's

impossible. You can do it for guns but you can't do it for knives."

The obvious answer, Feedback thinks, is to require all knives to be scented in future.

TRAVEL can certainly broaden your horizons, as Jeff Anderson discovered when he took a trip to Dublin. There, a local theatre offered him "a motion ride experience" in no less than six dimensions. "Journeys in my Ford Focus are never going to seem quite as exciting," he laments.

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

A rigorous assessment by the Economist Intelligence Unit has awarded the UK a new accolade: It is "the best place in the world to die".

Polar trader

If I bought 1000 tonnes of gold bullion in Antarctica and sold it in Mexico at the same price per kilogram, would I make a loss? Surely the consignment would be lighter at the equator than the poles because it is spinning faster?

Gravitational acceleration does indeed vary slightly over Earth's surface, partly through a combination of the planet being oblate (not perfectly spherical) and variations in the forces alluded to in the question.

There are also more localised contrasts, caused by differences in rock density and large-scale topographical features – the sea level around Greenland, for example, is higher than it would otherwise be because of the large mass of water contained in glaciers. Further minor short-term fluctuations in apparent gravitational acceleration occur because of the relative motion of the sun and moon.

"We can estimate that 1000 tonnes of gold at the poles would reduce to 995 tonnes at the equator"

The Earth's spin reduces this acceleration by about 0.3 per cent at the equator, compared with the poles.

On top of this, the bulge of the planet at the equator means that objects here are further from Earth's centre than they are at the poles, giving another reduction of 0.2 per cent. An object will therefore weigh about 0.5 per cent more at the poles.

Mexico City is at an elevation of more than 2000 metres, which pushes it still further from Earth's centre. However, any additional effect is cancelled out by the fact that Mexico is still some distance from the equator.

We can thus estimate that 1000 tonnes of gold at the poles would reduce to a weight of 995 tonnes at the equator. So in theory, a sizeable profit could be made if you were to buy at the equator and sell at the poles.

However, in practice the cost of transportation and security would be prohibitive. And the laws of supply and demand suggest that you wouldn't get a good price when penguins or polar bears are the only customers. In addition, gold bullion is usually cast in ingots of a certified mass – so unless you could persuade your customer to buy on the basis of the values on your own scales, you would be in trouble.

Simon Iveson
School of Engineering
University of Newcastle
New South Wales, Australia

Fur-up ball

I live in a hard water area and use a stainless steel mesh ball in my kettle to stop it "furring up". The steel mesh traps the scale that would otherwise form inside my kettle. How does it work?

If you want to get rid of something, you can use a chemical, physical or biological agent – or you can provide a different environment that it prefers.

Some gardeners use sacrificial planting of nasturtiums to attract aphids and thus protect their prized plants, rather than using pesticides. Aphids can then be physically removed from the nasturtiums, or the most infected plant parts can be destroyed, leaving the rest to carry on the good work.

"Limescale is deposited on the steel mesh because it has more nucleation sites than the kettle"

In a similar manner, limescale is deposited preferentially on the stainless steel mesh ball because the mesh has far more nucleation sites than the kettle. These sites are discrete points, such as microscopic scratches, where the crystallisation of limescale (mostly calcium carbonate) starts. The mesh ball won't capture all the deposited limescale, but it can be periodically soaked in vinegar to dissolve the build-up and then reused.

Don't be tempted to use cheap wire wool bought in hardware stores. This will corrode and the rust will make your tea and coffee browner than usual.

David Muir
Science Department
Portobello High School
Edinburgh, UK

This week's questions

REVOLVING CORE

I keep reading about how every so often, Earth's north and south magnetic poles "flip". How long does it take for this to happen? Moments or years? And does the magnetosphere "turn off" when this change is taking place? Or is it more like turning a bar magnet through 180 degrees, with the poles moving across the planet's surface and passing through the equator?

Geoffrey Clark
Douglas, Isle of Man

REAL FEEL

In the summer, meteorologists always warn that it will feel hotter because of the humidity (the "real feel" temperature). In contrast, humidity seems to exacerbate the feeling of cold in the winter. At what point does humidity cause the ambient temperature to feel hotter or cooler?

Deborah Fenker
New York, US

LAUNDRY STIFFENER

To do our bit for the planet, we have been hanging our washing on a line in the back garden rather than using our electric tumble dryer. Thicker materials such as bath towels and socks are hard and abrasive when dried on the line, in comparison to the soft and fluffy feel of the tumble-dried versions. Why does this happen?

Ronan Tierney
Enniscorthy, Ireland

The writers of answers that are published in the magazine will receive a cheque for £25 (or US$ equivalent). Answers should be concise. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and an email address if you have one. New Scientist retains total editorial control over the published content.

Reed Business Information Ltd reserves all rights to reuse all question and answer material that has been submitted by readers in any medium or in any format and at any time in the future.

Send questions and answers to The Last Word, New Scientist, 110 High Holborn, London WC1V 6EU, UK, by email to lastword@newscientist.com or visit www.newscientist.com/topic/lastword (please include a postal address in order to receive payment for answers). Unanswered questions can also be found at this URL.

This cloud stands up to any storm.

Microsoft Azure scales to enable AccuWeather to respond to 10 billion requests for crucial weather data per day. This cloud rises to the challenge when the weather is at its worst.

This is the Microsoft Cloud.

learn more at microsoftcloud.co.uk

Microsoft Cloud